FIRST LESSONS

IN

AGRICULTURE

GULLEY.

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— BY —

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PREFACE.

In 1885 the Board of Trustees of the Agricultural College, of Mississippi, instructed its President to devise some means for giving instruction in Agriculture to students in the preparatory class. In accordance with the request of President, S. D. Lee, the author prepared the first draft of this work, and had a sufficient number of papyrograph copies struck off to supply the members of the preparatory class of 1886. The students evinced so much interest in the study that the author felt encouraged to revise the mattter, and to have it published in book form for further use.

The writer has aimed to discuss the more important principles which underlie agriculture in a plain, simple way, within the comprehension of students who have not studied chemistry, botany, and the other branches of science closely related to this industry.

The subject of every chapter is of such importance, and covers so much ground, that it could be fairly discussed only in a volume by itself; hence in this little book, but a few points are touched upon. After some years of experience in the instruction of college classes, the author has concluded that impressing facts upon students is of minor importance when compared with awakening interest, in the study of agriculture; and this book has been prepared in compliance with that view.

It is believed that the practical farmer may receive suggestions from this work that will be of value to him. It may incline him to study the laws of nature with greater interest, and may lead him to make better use of the knowledge gained from those scientific investigations that pertain to the treatment of the soil for the purpose of securing larger returns in crop.

Not aiming to present a scientific treatise or even a work of reference for advanced students, the author has drawn material from all sources at his command, without referring to, or quoting directly from authors, in the text of the book. It was believed that the book would be more satisfactory if the matter was presented in a more condensed and simple form than is desirable in a complete work of standard character. Material has been collected from Johnson's "How Crops Feed and How Crops Grow," "Physiological Botany,"—Goodale. "The Chemistry of the Farm,"—Warrington. "Manual of Cattle Feeding," —Amsby. "Talks on Manures,"—Harris. "Elementary Principles of Scientific Agriculture,"—Lupton. "The Science of Agriculture,"—L. Loyd. "Stock-breeding,"—Miles. "Draining for Profit and Health,"—Waring. Bulletins of the Connecticut, New York, New Jersey and North Carolina Experiment Stations.

The above works are recommended for a further study of the topics briefly discussed in this little book.

Fearing that a few of the terms necessarily used to convey a technical meaning may be unfamiliar to a portion of my readers, a glossary explaining the meaning of some of them will be found in an appendix.

I am indebted to Dr. W. J. Beal and Dr. R. C. Kedzie of the Michigan Agricultural College, and to President S. D. Lee, and my colleagues Professors, D. L. Phares, J. A. Myers, and W. H. Magruder, of the Mississippi Agricultural College, for many valuable suggestions, also to Mr. N. D. Guerry of Artesia, Miss.

I am under a special obligation to Professor Magruder for help in preparing the matter for publication, and I have also been materially aided by my assistants, Mr. J. J. Huggins and Mr. W. W. Hoskins.

F. A. GULLEY.

Agricultural College, Miss.
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CHAPTER I.

Composition of Matter.

Elementary Substances.—Combinations of Elementary Substances. — List of Elements. — Elementary Substances of Interest to the Farmer. — The Atmosphere.—Lime.—Chemical Combination.

1. The Science of Chemistry teaches that all perceptible matter—the soil, the plant, water, the air we breathe—is made up of combinations of what are called elements.

2. An Element is the simplest form of matter. It can not be subdivided or split into parts composed of different substances. It can not be destroyed; but it will readily combine with, or attach itself to other elements, from which it may again be separated.

3. Something more than sixty-five elementary substances have been discovered or separated from their combinations with other elements, and their qualities and peculiarities studied and determined.

4. Elementary substances are not often found in uncombined forms, owing to the affinity which they have for one another. This attraction causes them to

form an endless variety of combinations, producing an almost infinite number of substances.

5. The elements, simple or combined, are found in three forms; solids, liquids, and gases—which forms are not permanent, since changes of temperature will cause most substances to appear in all three forms. For example: water, a liquid at ordinary temperatures, becomes ice, a solid, if reduced to a temperature of 32° Fah., and it becomes steam, an invisible gas or vapor, if heated to 212°. The ice upon being warmed, loses its solidity and becomes water again; while steam is again visible as a liquid if allowed to become cool.* In like manner the metals, iron, lead, copper, etc., as well as the soil and rocks, which are solids at ordinary temperature, may be made to pass into the liquid and gaseous forms by applying sufficient heat.

6. Wood or vegetable matter, is not melted by the application of moderate heat, but part of the elements of which it is composed is driven off as gases, and the ashes or earthy matter left may be converted into the liquid and gaseous forms by intense heating.

* When steam escapes from the boiler into the air it can be seen; but it is no longer in the vapor form, having cooled into minute drops of water. If water is boiled in a glass flask or bottle no steam is visible until it escapes and meets the cooler atmosphere.

7. The following elements have been separated and named

Aluminum	Gold	Potassium
Antimony	Hydrogen	Rhodium
Arsenic	Indium	Ruthenium
Barium	Iodine	Selenium
Beryllium	Iridium	Silver
Bismuth	Iron	Silicon
Boron	Lanthanum	Sodium
Bromine	Lead	Strontium
Cadmium	Lithium	Sulphur
Cæsium	Magnesium	Tantalum
Calcium	Manganese	Tellurium
Carbon	Mercury	Thallium
Cerium	Molybdenum	Thorium
Chlorine	Nickel	Tin
Chromium	Niobium	Titanium
Cobalt	Nitrogen	Tungsten
Copper	Osmium	Uranium
Didymium	Oxygen	Vanadium
Erbium	Palladium	Yttrium
Fluorine	Phosphorus	Zinc
Gallium	Platinum	Zirconium

8. Less than one-fourth of these elements are known to have any influence on the soil or the plant, from an agricultural stand-point; but the list is given to enable the student or the reader to refer to it, if desired.

9. The student of agriculture is concerned with but fourteen or fifteen of the elementary substances, as from these are formed the animal, the plant, and the soil constituents that enter into the composition of the animal and plant.

Plants are composed of:

NON-METALS:	METALS:
Oxygen	Potassium
Hydrogen	* Sodium
Nitrogen	Calcium
Carbon	Magnesium
Sulphur	Iron
Phosphorus	
* Silicon	
* Chlorine	

*Silicon, Chlorine and Sodium are not believed to be essential to plant growth although found in most plants.

Besides the above, Aluminium, Manganese, Iodine, and some others are found in minute quantities in plants, but are not supposed to be necessary to their development.

10. The atmosphere, or air we breathe, is composed principally of two elements in the gaseous form, Oxygen and Nitrogen: four parts of Nitrogen to one part of Oxygen. Oxygen and Nitrogen are invisible at ordinary temperatures, either when alone, or when mixed, as in the atmosphere, yet they will change to liquids, if subjected to intense cold. They may be found in nature combined with other elements in the liquid and solid form.

11. Pure water is a chemical combination of oxygen and hydrogen, both of which will assume the gaseous form if separated.

12. Limestone, a hard and widely distributed kind of rock, is composed of the elements, carbon, oxygen, and calcium, with some other matter that may happen to be present as impurities, and is known as carbonate of calcium.

13. The lime of commerce, such as is used for making mortar, if pure, is composed of oxygen and calcium. It is made by burning limestone in a kiln, the burning simply driving off the carbon and part of the oxygen. The lime differs from the limestone from which it is made in having strong caustic or corroding properties, and a strong affinity for water.

14. When water is added to fresh lime, heat and steam are produced by the combination of the elements contained in the water with those of the lime, and the lime is said to be "slaked." If not too much water is added, a dry, fine, powder is the result, which consists of lime and water; but, in the process of combination, the water is changed from a liquid to a solid, adding weight and bulk to the lime.

15. If fresh lime is exposed freely to the air, moisture is slowly absorbed from the atmosphere, producing what is known as "air slaked" lime. At the same time carbon and oxygen in the form of

carbonic acid, (a compound always existing in small quantities in the atmosphere) is also absorbed, changing the lime back again to carbonate of calcium; or carbon, oxygen, and calcium, the same material (limestone), from which the lime was originally derived.

16. In like manner two or more of the elements are combined together to form all substances with which we are familiar. Soils, plants, trees, animals, liquids, etc., are simply several elements combined. Elements that are in the soil in the spring may pass into the plant during the summer, be absorbed into the animal that eats the crop, and the manure from the animal may go back to the soil and carry the same elements back to supply the succeeding crop, the same round being repeated again and again.

17. The changes just referred to are chemical combinations, a process by which the elementary substances contained in one material, combine partially or wholly with those of another, and it differs from what is termed a mechanical combination or mixture; although in the latter we may have a compound that is quite unlike the materials from which it is made.

18. One substance may dissolve and disappear in another without changing the bulk or appearance of the latter, as when salt or sugar is added to water.

19. In practical agriculture, when we grow a crop, feed it out to stock, and apply the manure made to the soil for the succeeding crop, we are simply putting

back what the crop had taken from the soil and air; but owing to the changes in the combinations of the elements contained, the substances appear in a different form. The crop itself, if applied as a fertilizer, would after decay, have nearly the same effect as the application of the manure made by feeding the crop to stock.

20. The elementary substances are themselves unchangeable; that is, one will not turn into another. An atom of oxygen is always an atom of oxygen, no matter what it may combine with.

21. The elementary substances can not be destroyed. If we take a stick of wood, which is composed of carbon, oxygen, hydrogen, and some mineral or ashy matter, and burn it, we simply cause the gaseous elements, carbon, hydrogen, and oxygen, to pass off into the air, while the mineral matter remains as ashes. If the ashes are applied to the soil, they become soluble and may in time be taken up by the roots of plants to help make new wood, while the three gases may be taken up by the leaves, or, if carried down to the soil by rain, by the roots of plants, and again appear in the solid, woody form.

22. Polished iron exposed to moist air is covered with a coating of rust, produced by the oxygen of the air combining with the iron. The iron is oxidized, or burned, just as wood is burned in fire; but the combustion is very slow, and does not produce sensible heat.

CHAPTER II.

Origin and Formation of Soils.

Rock Formation.—Conversion of Rock into Soil.—Mechanical and Chemical Decomposition.—Organic and Inorganic Matter.

23. Geology teaches that the earth was once an immense body of melted matter. As the molten mass cooled, a crust of rock was formed on the surface, and this rock, broken up by the action of moisture, heating, freezing, the wearing effect of running water and moving ice, and decomposition due to the action of the atmosphere, has been changed into soil.

24. The breaking down of solid rock and formation of soil is constantly taking place, and may be seen wherever rock is exposed to the action of the air, water, heat, and cold.

25. The stone building or bridge, the monument, the hardest granite, all slowly crumble down unless protected from the action of the weather, and even the soil itself decomposes, breaks up into finer particles, although the finely broken rock may again unite and become a solid mass if protected from the weather and allowed to remain undisturbed.

26. Rain falling on the crumbling rock washes the finely broken particles down the hill-sides and into the streams

27. The sediment deposited by the streams of water and moving ice, and crumbling of the exposed surface, has covered the rocky crust of the earth with a layer of soil varying in thickness from an inch to hundreds of feet.

28. In addition to the material formed from the finely broken rock, most soils contain more or less of the remains of plants and sometimes animals, so that ordinary soil is made up of mineral substances called inorganic matter, and vegetable and animal remains, called organic matter.

29. Plants, either growing or decaying, help to form soil from broken rock, while the worms and minute organisms in the earth aid in the same way to make the soil fine, and fit it for the better growth of plants.

30. Soil is formed from rock and fitted for the growth of plants through mechanical decomposition, simply breaking up into small particles, and chemical decomposition, separation of the elements that enter into the composition of the rock.

31. Organic matter, as generally understood, means material formed or collected in animal or plant growth that can be driven off by heat.

32. To determine the amount of organic matter contained in a soil, a sample of the soil is thoroughly dried, carefully weighed, then heated to a low red heat. After having been heated, it is again weighed, the loss in weight from the portion driven off by burning represents the organic matter.

33. The inorganic matter of the soil, or of a plant, is the part that remains after the organic material is burned off. Pure and clean sand, clay, etc., are samples of inorganic matter, while the remains of the roots, stems, and leaves of plants, and skin, hair, and tissues of animals contain the organic matter.

34. All soils that have been recently covered with any kind of plant growth, contain organic matter varying ordinarily in amount from one to ten per cent., while marshy or peaty soils may contain several times as much.

35. Continuous cultivation of land will reduce the amount of organic matter in the soil, unless some means are taken to renew the supply, while in woodlands, and land allowed to grow up in grass and weeds, the organic matter will increase.

36. By alternating cultivated crops, such as corn and cotton with grass and clover, a sufficient supply of organic matter may be retained in the soil.

CHAPTER III.

Composition of the Soil.

Classification of Soils.—Heavy Soils.—Light Soils.—Fertile Soils. — Productiveness. — Condition of Elements Required to Support Plant Growth.—Rendering Soil Elements Available.

37. Soils differ widely in composition and condition, varying according to the materials from which they are formed; yet we find certain elementary substances in nearly all soils.

38. A soil composed largely of pulverized limestone is called a marl, calcareous, or lime soil; of sandstone, a sandy soil; of alumina, a clay soil; of partially decomposed vegetable matter, such as we find in swamps and marshes, a peaty or mucky soil.

39. If the soil contains a large proportion of clay, it is sticky when wet, dries out slowly, is hard and compact when dry, and is called a heavy soil. If made up largely of sand, it dries out more rapidly, is not sticky when wet, remains loose and porous when dry, and is called a light soil. All of these soils may be equally productive if they contain a sufficient amount of the elements required in plant growth,

that are in the right condition, and do not contain materials that are injurious to plant growth.

40. The term, light soil, as ordinarily used, means simply a loose or coarse grained soil. A cubic foot of dry sand weighs from 110 to 120 pounds, of loamy soil, (sand and clay mixed) 90 to 100 pounds, a nearly pure clay soil 70 to 80 pounds, and peat or muck from 30 to 50 pounds.

41. All fertile soils contain more or less aluminum, calcium, carbon, chlorine, iron, magnesium, manganese, phosphorous, potassium, silica, sodium, and sulphur, in their combined forms, and organic matter containing nitrogen, oxygen and hydrogen. The other elements are found more or less widely diffused in soils, sometimes in considerable quantity and variety, while again they may be entirely lacking, or found only in minute traces. They are not of special importance in agriculture, unless found in sufficient amount to be injurious to plant growth.

42. The productiveness of the soil depends more upon the condition than upon the quantity of the elementary substances in it. Soils may contain large amounts of all the elements required for plant growth; yet, if the elements are not in the proper condition, the plant or crop may not be able to make use of them.

43. A rock may contain elements that will make plant food; but, unless the rock is broken up and

made soluble, the plant can not absorb them. Two or more elements may be combined in such a form that they are not available to plants, and a new chemical combination must take place to fit them for plant food.

44. The application of barn-yard manure, commercial fertilizers, lime, ashes, plowing and cultivating, turning under green crops, in fact, the addition of any substance to the soil that will form new combinations of the elements in it, or any treatment that will give access to the air to promote decomposition of soil matter, tends to prepare inert matter in the soil for plant food. Filling the soil with the roots of plants, and then allowing them to decay, will have the same effect. Shading the soil by growing such crops as cow-peas, clover, grass and weeds, or covering it with straw and litter of any kind will tend to increase the amount of available plant food and make the land more productive. The farmer should study all these methods of improving the condition of the soil to enable him to increase the fertility in the most economical way.

CHAPTER IV.

Composition of the Plant.

Requirements of the Plant. — Elements found in Plants.—Enriching the Soil. — Exhausting the Soil.—What should be Sold from the Farm.— Natural Restoration of the Soil.

45. Plants are composed of combinations of certain elements that are drawn from the soil and the atmosphere. These elements must exist in available form in the soil and air, or the plant will not grow. All of the ordinary farm crops contain the same elements, in different proportions; but one plant may have the power to take material that is not accessible to other plants, from the soil to make growth. For this reason some soils are best adapted to one crop and some to another.

46. It has been found in planting seed in prepared soil that ten elements are required to enable plants to grow. Four of these elements may be supplied from the atmosphere, but the other six must be present in the soil.

47. The elements believed to be necessary for plant growth, are: oxygen, hydrogen, carbon,

nitrogen, calcium, potassium, phosphorus, magnesium, sulphur, and iron.

Sodium, manganese, silicon, and chlorine are generally found in plants, besides traces of several other elements, but these are not thought to be necessary to their growth

48. Oxygen, hydrogen, carbon, and part of the nitrogen are supplied by the air and rain; the remaining elements, by the soil.

49. Animals live on plants or on other animals; hence the body of the animal is composed of the same elements that are found in plants, and the remains of animals and plants applied to the soil as a fertilizer will furnish plant food to growing crops.

50. Well cultivated soils generally contain a sufficient supply of the elements named, in an available form, except potassium, phosphorous and nitrogen. Four-fifths of the atmosphere is composed of nitrogen; yet the plant can not use this nitrogen unless it is combined with hydrogen in the form of ammonia, or with other substances in the soil, and made soluble so that the roots of plants can absorb it.

51. Crops that draw large amounts of the nitrogen compounds, potash, and phosphates from the soil, exhaust the soil rapidly; while crops that contain only small amounts of these three materials, and do not remove much besides carbon, oxygen, and hydro-

gen—elements supplied by the air—do not exhaust the soil rapidly.

52. The marketable parts of some crops contain only small amounts of the elements that exhaust soil by being removed; hence, if the remainder of the plant is returned to the soil, fertility is retained. Cotton lint is composed almost entirely of carbon, oxygen, and hydrogen, elements supplied by the air and rain; therefore, if the seeds, leaves, and stems are returned to the land, fertile soils may be cropped for years without much deterioration.

53. Cotton seed is rich in fertilizing materials, and should be used on all farms to feed to stock, and the manure should be returned to the land, or else the seed applied directly for manure. The oil of the seed is composed of carbon, oxygen, and hydrogen, and is of no particular value for manure; hence, there would be no loss of fertility if the seed were sold, and as much cotton seed meal and cotton seed hulls as the seed contained, purchased and returned to the land.

54. Wheat flour is made up largely of carbon, hydrogen, and oxygen; therefore if the wheat bran and wheat straw are fed to stock, and the manure produced returned to the soil, but little loss of fertility will occur.

55. The leaves of the tobacco plant contain large

amounts of the fertilizing elements; and, as the leaves constitute the part that is sold, tobacco wears out land rapidly.

56. A study of the composition of plants will enable the farmer to grow and sell such crops, or such parts of the crop, as will not remove any considerable fertility, and it will suggest also the importance of purchasing feed stuffs that will make rich manure.

57. It will be noticed from what has been said in this chapter, and in the chapter on Soils, that plants are composed of elements drawn from the soil, with the addition of such elements as are supplied by the air and rain. If, therefore, a plant grows, and remains on the land to decay, the soil will receive back what the plant has taken up and also what the atmosphere has supplied. In addition to what the plant gives back to the soil, the decay of the stems, roots, and leaves renders soluble inert material in the soil. In this way nature restores the worn out lands that have become impoverished by continual cultivation without the application of fertilizers. The growth and decay of grass and weeds on land that has been "turned out," slowly enriches it, and, if the soil is not washed away, will, in time, make it again productive when cropped.

CHAPTER V.

Plant Food in the Soil.

Support of the Plant.—Fertile Soil.—Why New Land is Productive.—Retaining Fertility.—Value of Natural Fertility.

58. Plants, like animals, must be supplied with food to live and grow. The food of the plant is taken up by the roots from the soil, and absorbed through the leaves and green parts from the atmosphere. In practical agriculture we are chiefly concerned with what is taken up by the roots, that is, with the plant food in the soil.

59. If a soil contains an abundance of all of the elements that enter into the composition of the plant, and if these elements are combined in the proportion to pass into the condition that will permit of absorption by the roots of plants, the soil is said to be fertile, provided the temperature of the soil and air is suitable, a proper amount of moisture present, and there are no substances in the soil that may act as a poison to the plant.

60. A totally barren soil, (one containing no plant

food) can be made to grow plants by supplying the above requisites.

In practical work the cost of the material added to produce the crop might exceed in value the product secured; therefore land may be too poor to be worked profitably.

61. New land, when first broken with the plow, contains usually an abundant supply of plant food, and will produce large crops. In forest and wild prairie growth, the leaves, stems, etc., of the trees, grasses, and other plants, fall on the ground, decay, and constantly add plant food. In growing a crop and removing the product, plant food is carried away and thus the soil is exhausted.

62. If the crop is fed out to some kind of stock, and all the manure made is carefully saved and returned to the land, the soil receives all that has been taken away except the small amount stored up in the body of the animal.

63. From this will be seen the necessity for keeping some stock on the farm, and the growing of feed crops on at least a portion of the land to make manure, instead of producing crops for sale only, such as cotton, wheat, and tobacco.

64. Land may be cultivated for any length of time without loss in producing capacity, if plant food in the form of barn yard manure, or other fertilizers is

supplied. The manure simply contains the elements that the crops require, or it has the power to make available to the plant what the soil contains. Under an intelligent system of farming the soil should not become less productive.

65. The solid rocks are made up partly of elements that enter into the composition of plants, but in the form of rock the plant can not make use of them. The elements in the rocks and in the soil are often combined together in such a way as to be out of the reach of plants. The rocks are pulverized by being exposed to the sun, rain, heat, cold, etc., and particularly to the action of the oxygen of the air, and the elements of which these rocks are composed form new combinations. Ploughing land, and repeated cultivation of the crop while growing, though they add no new material to the soil, furnish plant food by making available that which is already in the soil. Applications of lime, plaster, (sulphate of lime) salt, ashes, etc., will often aid plant growth and increase the crop, not so much from the plant food they contain, as from the decomposition of inert matter in the soil caused by the application just mentioned.

66. Certain soils that have been cropped for many years without the application of any fertilizer, still produce large crops. This is true where a considerable amount of plant food is stored in the soil, which slowly becomes available through chemical changes

in its condition. Examples of such soils are found in valleys and bottom lands where a thick layer of rich soil has been deposited by overflow.

67. Soils that contain considerable amounts of clay or lime, are usually lasting soils, while sandy soils, as a rule, soon wear out, unless fertilized, notwithstanding the fact that they are generally more productive when fresh than are the heavy soils.

68. Low, wet lands, as a rule, contain more plant food than uplands, and will be found most profitable to work, provided they can be effectually drained at an expense not too great.

69. In purchasing land for a farm, the choice should be governed largely by the amount of plant food the soil contains, as this will determine to a considerable extent the cost of keeping the land in a profitably productive condition.

CHAPTER VI.

MECHANICAL CONDITION OF THE SOIL.

Effect of Compact Soil on the Plant Food Contained.—Fertilizers. — How to Improve. — Drainage.—Shallow and Deep Cultivation.—Fall Plowing.—Treatment of Sandy Soils.—Muck and Prarie Soils.

70. It is stated in the preceding chapter that soils may contain large amounts of all the elements required by plants to make growth, and yet may fail to produce profitable crops. This result is often due to the fact that the soil is not in a proper mechanical condition.

71. A close-grained, compact soil will not freely admit air, water, and heat; requisites for supplying the roots of plants with plant food; nor can the roots penetrate the soil readily. The feeding power of the plant is governed largely by the extent of its root growth; hence, if the roots can not spread all through the soil, full development will not take place.

72. If the air can not enter the soil, chemical decomposition of substances that contain inert plant food will be prevented; and from this source the crop

may be largely supplied Fertilizers applied to such soils give light returns, unless they change the texture of the soil; hence, the improvement of the mechanical condition of many soils is of prime importance.

73. The compact condition of the soils referred to is due to several causes, but more often to excess of water in the soil during portions of the year (lack of drainage) than to any other.

74. Soils composed largely of clay and containing but a small proportion of sand or of vegetable or organic matter, will become compact from continual shallow plowing and cultivation, working heavy land, or allowing stock to run on it while it is wet, will produce this condition.

75. Heavy, compact clay soils are benefitted by the application of sand to lighten them up; but such an application is usually too costly to be practicable. Nearly all clay soils will become compact and heavy to work, if kept in clean cultivated crops for several years, when the crops are entirely removed from the land.

76. If the cultivated crops alternate with grass, clover, peas, or any growth that will fill the soil with roots, or which leaves a considerable quantity of vegetable matter on the soil, this material when plowed up or under, will slowly decay, and will keep the parti-

cles of the soil separate and loose; green crops plowed under, the application of coarse manure or litter of any kind, such as leaves, straw, weeds, etc., will have the same effect.

77. Clay land plowed, worked, or tramped by stock, when wet, is puddled, the particles of soil being pressed firmly together and remaining so when dry. If the soil contains considerable lime, the injury is not so serious, since, in drying, the lime will cause the soil to crumble and will thus break up the clods.

78. Shallow plowing, and cultivating only two or three inches deep, will stir the surface only, and will compact the sub-soil, often forming a hard-pan a few inches below the surface, almost impervious to air, water, and the roots of plants. The serious effect of such cultivation is shown in the "burning" of the crop in dry weather.

79. When the heavy condition is due to excess of water, this being the most common cause, the only remedy is drainage, which subject will be discussed in a chapter by itself.

80. From what has been said it will be understood, that the way to improve heavy, compact soils, is, first to drain them; second, to give deep and thorough cultivation when dry, and keep stock from running on the land when wet; third, to alternate clean cultivated crops, like cotton and corn, with grass and hay

crops, or to plow under an occasional crop growing on the land, such as grass, clover, peas, grain, or even weeds

81. Fall and early winter plowing, after land is well drained, will be found beneficial on most heavy soils, simply breaking the land with double plows and leaving it without harrowing.

The author has added 25 per cent. to the succeeding crop by plowing heavy bottom land in the fall.

82. Sandy lands require different treatment from heavy clay soils. They generally need compacting instead of loosening. Shallow plowing and cultivation, and even working when quite wet, are often beneficial. The addition of vegetable matter in the way referred to in the treatment of heavy soils, will also be of great advantage in filling the open spaces in the soil with a fine material that will help to retain moisture, and prevent fertilizing matter from leaching out.

83. Muck soils, marsh, and fresh prairie land, are too open and porous, and they contain too much organic matter to grow large crops. They require different treatment from either light sandy, or heavy clay soils to be made productive. If wet, they must first be drained, and after that, the more thoroughly the surface soil can be exposed to the action of the oxygen of the air, to decompose and get rid of the excess of organic matter, the sooner will they produce good crops. Plowing should be shallow at first, and as long before planting as posssible.

CHAPTER VII.

Effect of Water on the Soil and Crop.

Absorption of Water by the Plant.—Water in the Soil.—Influence of Wet Soil on Crops.—Drainage.

84. Plants require considerable quantities of water during the growing season, when the leaves are exposed to the free air.

85. The water is absorbed from the soil by the roots and thrown off from the leaves. If the supply of water becomes exhausted or is not sufficient for the requirements of the plant, it wilts, growth is checked, and the plant may finally die. If the leaves on the plant are removed, evaporation of water is stopped, and in this leafless condition the plant may be kept alive but in a dormant state, for a considerable time. In a moist atmosphere, evaporation from the leaves is checked and less water is taken up from the soil by the roots.

86. Soils that dry out rapidly by evaporation from the surface, or from drainage through a coarse and loose sub-soil, can not be relied upon to grow crops in dry seasons.

87. An excess of water in the soil is injurious to many plants. With the exception of the coarser grasses and sedges and a few other plants, farm crops will not grow and thrive on land that is saturated with water.

88. If the soil is wet during the spring and early summer, and dry the remainder of the season, it will not produce abundant crops. As a rule, crops planted on such soils suffer most during droughts. This result is due to several causes:

1st. Heavy soil that is wet in the spring can not be properly prepared for planting.

2nd. Heat will not penetrate a wet soil, and where water stands near the surface, the rapid evaporation will keep the soil cold, regardless of the temperature of the air, thereby tending to make the seed rot or produce a weak and sickly growth.

3rd. The roots of plants growing on wet land will spread out near the surface instead of descending into the soil. The roots do not reach fertilizing material stored in the soil, the plant food in the soil will not become available so long as it is sealed up by a covering of water, and again, when the soil dries out during mid-summer, the roots lying near the surface in the hot dry soil can not take up water, they dry up and the crop is "fired" or burned up before it matures.

4th. Large quantities of water evaporting from the surface of the soil, makes the soil compact and solid, impervious to the air, and heavy to work.

89. Drainage alone will correct the evils referred to in the preceding paragraphs, and drainage of some kind is the key-stone of successful farming on all heavy, close level, or bottom lands.

90. On rolling uplands that wash readily, control of the surface water is an absolute necessity to prevent destruction of the land for farming. The fertile surface soil of the hill lands is washed down into the streams and carried away, and the rich bottom lands are buried under a deposit of sand and clay. The ditches and creek channels are filled thereby, preventing drainage, and both hills and bottoms are made unprofitable to cultivate.

The effect of uncontrolled surface water washing over the land has reduced the fertility of the soil over considerable portions of the Gulf States to a much greater extent than has been caused by continual cropping and making no return to the soil in the way of manures.

CHAPTER VIII.

Farm Drainage.

Supply of Water for Plants.—Advantages Derived from Drainage.— Protection from Drought.—Kinds of Drainage.—Tile Drains versus Open Ditches.— Hill-side Ditches.— Terraces.— Horizontal Cultivation. — Construction of Hill-side Ditches.— Drainage Ditches.—How to make a Level.—Leveling for Ditches —Making the Ditch.

91. Farm drainage includes ridding the soil of excess of water to the depth of two or three feet as well as the removal of surface water.

92. To insure rapid growth and development of most farm crops, the soil should be moist, but not wet. If the excess of water in the soil is drawn off through under-ground drains, sufficient water may still rise from the moist sub-soil by capillary attraction to supply growing plants

93. A well drained soil becomes porous and sponge-like in its character, and will absorb and hold water supplied by rain, that would run off on the surface of any undrained and saturated soil. Thorough under-ground drainage on heavy soils tends to store up

water and retain it in the soil until needed, and prevent the rapid filling of creeks, and also destructive over-flows after heavy rain storms.

94. Crops on drained land are not liable to suffer from lack of rain in dry seasons, because the land can be more deeply and thoroughly fitted for the crop before planting; cultivation is more effective, and less costly, and the roots of plants will be largely increased and will penetrate deeper. As a consequence they will not be affected by dry, hot weather, and there will be less evaporation of water from the surface than on undrained land.

95. A strong, vigorous, well-rooted plant will thrive through a dry, hot or cold spell, where a shallow-rooted, weak plant would die; hence, drainage and good cultivation will carry crops safely through any ordinary dry season.

96. Drainage is of two kinds: surface and sub-soil. Surface drainage is where the water runs off over the surface, or is carried off in shallow ditches Sub-soil drainage is where the water sinks down into the ground through a porous sub-soil, or is carried off from the sub-soil through tile or other under-ground drains or seeps into deep ditches.

97. The effect of deep open ditches, or tile drains, is practically the same, except that the open ditches occupy a good deal of land, and are in the way of cultivation, carry off soil and manure by washing,

and require constant attention and labor to be kept in order, while tile drains are permanent and require no room, or further attention after being constructed.

98. Ditches and tile drains two and one-half feet to four feet deep are preferable to shallow drains. Shallow open ditches do not drain land; they simply carry off surface water. When properly located they may prevent the soil from washing on sloping lands, but they do not remove the excess of water in the soil.

99. Surface drainage, in the form of terraces or hillside ditches, is a necessity on cultivated hillsides to protect the land, if the soil washes readily, sometimes even if the land is tile-drained. On some soils in the Southern States, during heavy and protracted rains, the water will not sink into the soil fast enough to prevent washing over the surface.

100. Terracing land means throwing up ridges or embankments of earth across hillsides on a level, or nearly level, and then plowing down the hill until the hillside assumes the form of steps, or terraces, from bottom to top. The object sought is to make each terrace, or step, hold the water that falls upon it, and cause it to sink into the earth, or to flow off slowly to prevent washing.

101. Horizontal cultivation, running the rows of cultivated crops on a level around the hill, has, to

some extent, the same effect as terracing, and should always be practiced where the soil tends to wash.

102. Hillside ditching is somewhat like terracing; Low embankments or shallow ditches are constructed along the hillside, giving, however, sufficient fall to the ditch to allow the water to run off freely. Either plan will protect the soil from washing if the terraces or hillside ditches are properly constructed and kept in order. Terraces are preferable to hillside ditches, requiring but little attention after being made, while the ditches require constant repairing and cleaning to prevent filling or washing out too rapidly. Horizontal cultivation must in all cases accompany terracing or hillside ditching to make the work successful.

103. In laying off all ditches the capacity of water for carrying soil should be carefully considered. The more rapid the flow the deeper the stream, the finer the particles of the soil, and the more readily they separate when wet, the greater will be the capacity of the moving water to wash away soil. From the preceding statement it will be seen that no definite rule can be laid down as to the fall that ditches should have to enable the water to scour them out clean, and yet not cut out deep channels or gullies.

104. In practice it is found that hillside ditches should have a fall of from one to three inches to the rod, varying with the kind of soil, length of the

ditch, and amount of water to be carried. Whatever the fall given, it should not materially decrease towards the outlet of the ditch. If the flow of water is retarded at any point by less fall in the grade of the ditch, soil that is washed down from above by the swifter current will be deposited, the ditch will fill up with sediment, overflow, and the water, running directly down the hill, will cut out deeper gullies than would be formed without ditches. Owing to this result from the faulty construction of hillside ditches, many farmers are led to believe that land will wash worse with hillside ditches than without them.

105. The same caution that is required in the location and construction of hillside ditches, should be observed in laying off all ditches through nearly level or bottom lands, otherwise the ditches will fill wherever the current of water is retarded. Even large rivers from sand bars fill up and overflow where the speed of the current is materially checked by decrease in the fall.

106. Ditches of all kinds should be located or laid off with some kind of a level. An ordinary carpenter's spirit-level may be rigged up for the purpose, but an engineer's telescope-level is more convenient and accurate.

107. To rig the carpenter's level for locating ditches, have it adjusted so that the glass tube con-

taining the bubble will be level with the upper surface of the wooden bar in which the tube is set. Bore a small hole through the bar in the center and attach with small bolt to the side of a light staff about five feet long. Sharpen the other end of the staff, or better, fit on an iron ferule drawn to a point, and the level is ready for use. Make also a measuring-rod of a light wooden strip, eight feet long, laid off in feet and inches, with the feet numbered, and the outfit is complete.

108. To lay off the ditch, if a hillside ditch, start at either end or any point on the line of the ditch, and stick up a wooden peg. Set up the level at any convenient point by thrusting the sharpened end of the staff into the ground, point the level in the direction of the wooden peg, and make the level plumb. Two persons are necessary, one to work the level and an assistant to handle the measuring-rod. Let the assistant stand the rod on the ground at the wooden peg, holding it lightly with one hand, raising or lowering the hand until the upper surface is in line with the eye of the person sighting over the level. Notice the height of the hand above the ground, as shown on the rod, then decide upon the fall to be given, to find the next point on the line of the ditch. Suppose the fall is to be two inches in fifteen feet, and that the line is to be run down the ditch. The man with the rod will raise his hand two inches on the rod, and

carrying it with him, step off five paces in the direction the ditch will run; then holding the rod vertical, end on the ground as before, the man with the level will adjust the level pointed at the rod, and sighting, will notice if the hand of the rodman is too high or too low; if too high the rodman will move down the hill until he finds a place that will bring his hand level with the line of sight, or if too low, move up the hill. When the point having the desired level is found, stick up another peg which will give the second point on the line of the ditch. Continue on as before until the entire line is run over, moving up the level occasionally, as the distance becomes too great to take sights readily. In working up the line of the ditch, the rodman would lower his hand at each change instead of raising it; or in running off a level terrace he would not change his hand at all. The distance between the stakes and fall to the rod can be varied to suit the circumstances.

109. The levels completed, the pegs will form a line on the ground with a uniform fall of two inches in every fifteen feet or five paces.

110. To construct the ditch throw up a bed or back furrow with a large two-horse turning plow on the line of the stakes, leaving an undisturbed foundation two or three feet wide underneath. If a small plow is used it will be necessary to use hose and shovels to complete the work. The ditch-bank must be high and strong enough not to give way in a

heavy rain. All weak places should be strengthened by building up with spade or shovel.

111. After laying off hillside ditches, the rows of crops should be laid off parallel, or nearly parallel, with the ditches. Some farmers prefer to give the rows, or water-furrows, a little more fall than is given to the ditches in order to carry the water into these ditches.

112. In laying off drainage ditches in land that tends to wash readily, the level should be used, and the ditch so located that the fall will be somewhat uniform, otherwise sediment will be deposited wherever the flow of water is retarded, and the ditch will fill up. Properly located and excavated, the ditch may be made self-cleaning if the water flows through it with nearly the same velocity from the source to the outlet.

CHAPTER IX.

Preparing the Land for the Crop.

Preparation of the Soil.—Plowing.—Large Implements.—Deep Plowing.—Thorough Preparation.—Planting on Ridges.—Value of Drainage.

113. The cost of cultivating a crop will be governed largely by the method of preparing the land before planting. While different soils require different treatment, the most successful farmers, as a rule, believe in and practice good plowing and thorough preparation.

114. It is not necessary that the soil should always be turned over with the turning plow, unless sod, weeds, manure, or other material on the surface is to be disposed of; but unless the soil is loose and fine, it should be thoroughly broken up and pulverized with the plow, harrow, or other implement.

115. No better implement has been found for preparing the soil on the average farm than the better styles of two and three horse turning plows. The steam plow or cultivator may do better work, but is not, as yet, found to be adapted to small farms.

116. Large implements and strong teams are

cheaper to use than small implements and light teams. One man can work two, three, or more horses or a large plow as well as he can work but one on a small plow, not only accomplishing two or three times as much work, but the work will be done better.

117. On some soils and with certain crops, large yields may be secured with slight preparation and little after cultivation, as in corn following cotton on clean land; but the best average results are secured from good deep plowing two to four or more times in every five years.

118. On nearly all old soils, maximum crops can be most cheaply secured by turning under some kind of sod or vegetable growth at intervals of from two to five years, in order to add organic matter to the soil and improve its mechanical condition.

119. The wider and deeper the furrow, the better such work can be accomplished, hence the necessity for large plows and strong teams.

120. The ground can be broken up more effectually in less time and with less cost before the crop is planted than to attempt to break out the middles between the rows after planting, as is often practiced in the Southern States. The best and largest cultivators can only be used in working the crop where the land has been well plowed and harrowed before planting.

121. The proper depth to plow will be governed by the kind and condition of the soil, crop to be grown, season of the year, time that will elapse before planting, and depths of previous plowings. As a general rule, plow sandy, loose, and wet soils shallow; heavy and dry soil, deep; shallow, if just before planting; deep, if some months before planting, as in fall and winter plowing for spring planting.

122. The succeeding crop may be injured by deep plowing, if the land has always been plowed shallow; but unless the subsoil is very poor, land containing much clay will be benefited by setting the plows to run half an inch or an inch deeper each year until the ground is broken eight to ten inches deep.

123. On well drained heavy soils fall or winter plowing will usually be found beneficial; but there may be some loss of fertilizing material from leaching in wet winter climates, where the land does not freeze. The harrow should be used after plowing and before planting, and on loose or lumpy soils the roller also, to make a fine and yet not too loose seed-bed. The smaller the seeds to be planted, the more thorough should be the pulverization of the surface soil to secure an even stand of plants.

124. Planting on beds or ridges, or planting on the level is more a question of drainage and temperature than of soil or crop. Well drained soil will

dry out and become warm early in the season, while wet land will not. The seeds of corn, cotton and many other plants will rot in cold, wet soils, when they would grow if the land was well drained; hence loose and dry land may be planted on the level, while cold, wet soils must be thrown up into ridges to provide a seed-bed sufficiently dry and warm to insure germination.

125. Level cultivation is preferable if the soil will permit, because the cultivator will do more rapid and effectual work on level land, a matter of considerable importance in the early cultivation of all crops. Tile drains dry out and warm up the soil early in the spring, and such drainage will enable the farmer to plow his land broadcast and plant crops on the level land.

CHAPTER X.

How Plants Grow.

The Ripening of the Seed.—The Annual.—The Perennial.—Reproduction of the Plant.—Sprouting of the Seed.—Assimilation of Food.—Functions of the Roots and Leaves.—Material Drawn from the Soil.—From the Atmosphere.—Source of Nitrogen.—Composition of Fertilizers.

126. The ripened seed represents the purpose of the plant's existence and the completion of its growth. The annual plants, such as corn, oats, and cotton, die after the seeds are formed, and the material collected during their growth decays, and is returned to the soil to provide plant food for succeeding plants. Perennial plants, which are such as live more than one year, become dormant for a time after the seed ripens and the leaves drop off; but, with the advent of spring, new leaves are formed, new blooms put forth, and after a time another crop of seed is ripened, this being repeated year after year, until finally the plant or tree dies from old age, or from disease, when the material of which it is composed decays, as in annual plants, and is returned to the soil.

127. To produce new plants, the seed may be planted; or in many plants, a piece of limb or root may be cut off from the living plant and placed in moist soil, from which roots and leaves will be thrown out, and a new plant produced of like character to those grown from planting the seed.

128. Careful examination of a kernel of corn will show that it contains a small chit, or germ, that is in reality an undeveloped plant, and, in addition a considerable amount of starchy matter closely compressed into the shell of the kernel. If the kernel is placed in a warm and moist place, as in the soil, it will soon become swollen, the germ will burst its covering, and a sprout will begin to develop. The sprout will appear in two parts, one of which will turn up towards the light, the other descend into the soil. The first is called the plumule, and from it will develop the stem and leaves; while the second, called the radicle, develops into the roots of the plant.

129. During the sprouting period, the plant lives upon the matter stored in the seed; but, with the appearance of green leaves and roots, it begins to feed upon material taken from the atmosphere and from the soil. The roots and the leaves or other green parts of the plant act as mouths to take in substances that will build up its structure.

130. From the roots proper, small rootlets branch out in every direction; and through the delicate outer

covering of the root hairs, moisture is absorbed from the soil, and with it, plant food of various kinds which is present in the soil in a soluble condition. By a peculiar process the absorbed liquid is carried up through the parts of the plant, and the water not required is evaporated, and, with some gaseous matter, is thrown off by the leaves. The rest of the matter is left in the plant, and becomes a part of its structure.

131. The leaves have two offices to perform; they throw off the excess of water taken up by the roots, exhale oxygen when exposed to light, and a small amount of carbonic dioxide, (carbon and oxygen) during the absence of light. They take up from the atmosphere large quantities of carbon dioxide in sunlight, retaining the carbon and exhaling part of the oxygen. They may take up ammonia, (a combination of nitrogen and hydrogen) when it is present in the atmosphere.

132. The plant receives from the atmosphere more than nine-tenths of its weight and of its bulk, which consists of carbon, oxygen, hydrogen, and possibly, a small amount of nitrogen in the form of ammonia.

133. The ash or mineral elements with the greater part of the nitrogen are taken up through the roots.

134. Four-fifths of the atmosphere is composed of free nitrogen; but nitrogen in its uncombined form

can not be assimilated by either the leaves or roots of plants. When, however, the nitrogen is combined with hydrogen, as in ammonia, it may be absorbed by the leaves, or by the roots, if it is in solution. In solution it can also be absorbed by the plant's roots, when it is combined with a base as in nitrate of soda, a combination of nitrogen and sodium.

135. Decomposition of animal or vegetable substances containing nitrogen forms ammonia, which passes off into the atmosphere; but, since ammonia has a strong affinity for water, it is carried down to the ground by every rainfall. The nitrogen of the air may also be made to combine with oxygen in the form of nitric acid, by electrical discharges, and may be carried in available condition by rainfall to the roots of plants; while recent investigations seem to show that free nitrogen may combine with some other element, in porous soil, and pass into the soluble form required to place it within the reach of the plant.

136. From what has been stated, it will be understood that in the preparation of fertilizers, it is unnecessary to use all of the elementary substances found in the plant. Our manure or fertilizer need contain only such elements as are not supplied by the atmosphere, and not supplied in sufficient amount in the proper form by the soil. Carbon, oxygen, and hydrogen are supplied in abundance, and a part of the nitrogen; the remainder must be contained in the soil

in a soluble condition, or supplied as a fertilizer, if we wish to produce a maximum crop. Such substances as oils, fats, sugars, starch, wood, and straw, composed almost entirely of carbon, oxygen, and hydrogen, have very little value as fertilizers, except to improve the mechanical condition of the soil, (see chapter 6); while lean meat, bones, seeds of most plants, and substances containing considerable quantities of nitrogen, potash, and the phosphates are usually of high fertilizing value.

CHAPTER XI.

Fertilization of the Seed.

Development of the Seed.—Structure of the Perfect Flower.—The Stamens and Pistils.—Impregnation of the Pistil.—Imperfect Flowers.—Fertilization of the Flower in Corn.—Cross-Fertilization.—Mixing of Varieties.—Propagation by Budding, Grafting, and from Cuttings.

137. The plant springs up from the seed, or takes on new life after lying dormant throughout the winter, as in the forest tree. It then throws out leaves and flowers; the flowers fade and in their places we find again the ripened seed.

138. The development of the seed from the flower is as intricate as the production of new life in the animal, and the process is somewhat similar.

139. If we examine a perfect or complete flower, such as may be found on the apple and many common trees and plants, we will find at the base of the flower next to the stem a circle of one or more leaves or parts, usually green in color, called sepals. Inside of these is another row of delicate leaves, not green in color, called petals, and inside of the petals

a cluster of little stems or hair-like projections, resting generally on the base or center of the flower, consisting of an outer row surrounding one or more of different form in the center.

140. The outer row of small stems are called stamens; the inner, pistils. The stamens and pistils are the important parts of the flower, the sepals and petals simply acting as a protecting covering. The stamens and pistils are the reproductive organs of the plant, and they are as necessary in their functions as the reproductive organs of animals.

141. At a certain stage in the development of the stamens, a fine dust-like substance, generally yellow in color, called pollen, is found. This is thrown off from the stamens, and if any of the pollen falls upon the pistil, the flower may be fertilized, or impregnated, and the seed will begin to develop at the base of the pistil, while the remainder of the flower withers and drops off.

142. In the apple, pear, melon, and similar fruits, the seeds are surrounded by the edible part part of the fruit; while in the strawberry the seed develops on the outer part of the edible portion. In the grains the seed is simply enclosed in a sheath.

143. In some plants the stamens and pistils are found in separate flowers (imperfect flowers) on the same plant, as in corn; and in still others the stamens are found in one plant and the pistils in an-

other, as in the willow and some varieties of strawberries. In such plants the pollen is carried from the stamens to the pistils by the wind, insects, or other agencies.

144. In corn the tassel, or flowers, at the upper extremity of the stalk, contain the stamens, while the silk on the young ear represents the pistils. Each fiber of the silk may develop a kernel of corn on the cob if a grain of pollen falls upon it; but if we cover the young ear before the silk appears, so that no pollen will come in contact with the silk, we will get simply a bare cob and no corn.

145. Different varieties of corn are found upon one cob when two or more varieties are planted near each other; the pollen from one variety fertilizing the flowers of another variety. This is called cross-fertilization. Bees and other insects, in entering the flower to collect honey, get the pollen on their bodies, and may carry it to the pistils of other flowers; in fact, in some plants a full crop of fruit or seed will not be produced unless the pollen is carried from stamen to pistil by insects. Red clover, beans, and pumpkins are partially fertilized through the aid of insects.

146. Owing to pollen often being carried considerable distances by the wind and by insects, it is very difficult to keep varieties of corn, cotton, and other plants pure.

147. In some plants that produce complete flowers, the stamens and pistils are so thoroughly enclosed and protected that the pollen can not be carried from one flower to another by insects or the wind; hence, there is no danger of such varieties becoming mixed even when planted side by side. Wheat is an example of this kind.

148. In many of our improved fruits and vegetables, the seed if planted will not produce the same variety as the plant upon which they grow. The grafted apple and Irish potato are examples. To secure the same variety in the renewal of such plants, cuttings, or buds are grafted onto roots or plants grown from seed, and only the limbs from the budded part allowed to grow. The Irish potato is simply an enlarged underground stem containing buds or eyes that will throw out stems and roots when the potato is planted.

149. Plants may also be propagated by cuttings; *i. e.*, taking off a small piece of stem on which there is a bud, and planting in moist, warm soil. Roots and leaves will spring from the cutting the same as from the seed; but while the flower that produces the seed may have been fertilized by another variety, thus forming a different plant, the cutting will produce the same variety of plant as that from which it was taken. Many of the best fruits and flowers have to be propagated from cuttings to retain the variety.

CHAPTER XII.

Improvement of Variety.

Natural Varieties. — Improved Varieties of Plants and Animals. —Selection.—Individual Variation.— Cross-Breeding. — Improvement of Corn. — Cross-Fertilization of Perfect Flowers.—Improvement of Grain.—Retaining Improvement.

150. The greatest success in farming can only be secured by growing the improved varieties of plants and animals. The improved varieties are made by modifying natural or wild growths. The wonderful improvement in varieties of animals and plants due to the skill of man can only be understood and appreciated, when we compare the qualities of our best breeds of animals, and varieties of fruits, vegetables, and other farm products with the native or wild varieties of the same species.

151. Natural varieties are the result of the influence of climate, food and other natural agencies; while the improved varieties owe their qualities to the influence of man in selection in breeding, in giving a liberal supply of food to make greater and more rapid development, and in elimination of all

inferior individuals to stop their further reproduction.

152. In the improvement of plants seed are taken from the best specimens, and planted on soil best adapted to promote full development. Continual repetition of this process will insure improvement in the qualities of the plant.

153. In animals, only such are selected to breed from as possess, to some extent at least, the desired qualities, all others being rejected. The offspring from the selected animals are fed and handled in such a manner as to develop the young animal in the desired direction. The treatment would include training (as in the case of the trotting horse, hunting dog and others), as well as liberal feeding. Skill in the selection of breeding-stock, and in feeding, handling, etc., will make some improvement in each succeeding generation.

154. Cross-breeding or cross-fertilization between individuals of different varieties or breeds to combine the merits of both in the offspring, is sometimes practiced successfully.

155. In beginning the improvement advantage is first taken of the individual variation found to exist in all kinds of plants and animals. In any crop that is grown on a farm, an occasional plant may be found that is superior to the average plant. If seed from this plant be saved, and planted on se-

lected soil, and if the same plan is repeated year after year, decided improvement may in time be made. By selecting seed continually, from early or late maturing plants, large or small specimens, etc., a change in the desired direction may be secured.

156. To make rapid and certain advancement in any desired direction in changing the character of a variety of plants, the fertilization or breeding of the flower must not only be controlled, but artificial or cross-fertilization must often be practiced. In artificial fertilization, we may sometimes be able to combine the merits of two plants in the plant grown from the seed thus produced.

157. Suppose that it is desired to increase the yielding capacity of a certain variety of corn, and we attempt to make two or more ears grow on each stalk. If we simply go through the field and select ears for seed from stalks bearing two or more ears, we would get ears containing kernels of corn that were fertilized possibly with pollen from stalks bearing but one ear, or no ear at all. If, however, we plant a small patch of corn off by itself, on good ground, and, just before the tassels are fully developed, go through the corn and cut the tassels from all stalks having less than two ears, we would have corn fertilized by two-ear stalks only, and we might certainly look for improvement.

158. By controlling the fertilization of corn for

several years in succession, in the manner described, planting on good soil, and cultivating thoroughly to develop the growing habit, the yielding capacity of any variety of corn may be largely increased. The productiveness of certain kinds has been more than doubled in this way.

159. Artificial fertilization of flowers having both stamens and pistils, is practiced by carefully removing the stamens from the flower with small nippers before they are fully developed, protecting the flower with a paper or cloth covering from pollen floating in the air, and when the pistil is ready, carrying matured stamens from the flower of the plant that possesses the desired quality, and carefully shaking the pollen off on the pistil to be fertilized. The plants grown from seed resulting from cross-fertilization may not have the good qualities of either parent, but occasionally valuable varieties are produced in this way.

160. Improvement by the simple selection of seed from the best plants is more certain in close-fertilized flowers, such as are found in wheat (see 146), than in plants like corn, where pollen is easily carried from one plant to another by the wind. The quality of the grain may be improved by blowing out light and small grains with a fanning mill and sowing the heavy grains.

161. A more rapid and certain improvement can

be secured by passing through the field of grain after it is ripe and selecting the best heads or stalks form which to save seed. Heavy, plump kernels are often found in inferior, short heads of wheat or other grain ; therefore a selection of the best heads is more certain to secure the best seed than simply sorting the seed after threshing the crop. Selecting the best ears of corn from a crib, or from the crop in the field, will make but little, if any, improvement, except what may be due to getting large ears that have been developed on strong stalks grown on the best soil in the field.

162. The valuable qualities of the improved varieties of animals and plants are artificial qualities, produced by artificial treatment. They are not permanent; therefore, when the influences that caused the peculiarities to develop are removed or neglected, the improved variety or breed deteriorates until it again becomes common or native stock.

163. In most improved varieties of plants and animals, early maturity and the increase of size, as well as better quality, are among the valuable things that have been secured through the improvement. This result is due largely to high feeding. The improved variety of corn that has been made to increase its yield two-fold has developed this quality from being planted on fertile soil, and it requires fertile soil to be able to make this large yield. In

the same way the beef breeds of cattle, or large butter yielding cows, have developed the habit of eating and digesting a large amount of food; hence they require liberal feeding to bring out their valuable qualities.

164. The man who half cultivates his land, or who works poor soil without fertilizing, or who half feeds his stock, gains nothing in attempting to grow any of the improved varieties of plants or animals.

165. The improved plant and the improved animal will require better treatment than the common varieties, but when supplied with this extra care they will make larger return in proportion to amount of land occupied, labor and food consumed, than the common varieties under any system.

CHAPTER XIII.

Cultivation of the Crop.

Object of Cultivation.—Preparation Before Planting.—Good Plowing. — Depth of Cultivation. — Fall Plowing.— Cultivation of Corn. — Shallow and Deep.—Hilling.—Turn Plow Cultivation.

166. Crops are cultivated by hand or by team-work to keep down weeds and promote rapid growth. During the growing season the crop should be kept clean from weeds to enable the plants to secure all of the available plant food and moisture that the soil will supply Oft repeated cultivation of the soil, if begun before the land becomes too dry, will tend to keep the soil moist through a dry season.

167. Plowing and thorough harrowing of the land, just before planting a crop that requires hand labor to destroy weeds, will reduce the cost of cultivation by enabling the crops to get the start of the weeds. Land infested with rapid-growing perennial weeds, should always be planted when the soil is freshly plowed and especially so if the seed to be planted germinate and grow up slowly. Seeds will germinate in less time if planted in freshly prepared soil than

they will if planted sometime after preparation, owing to the freshly plowed soil being moist and breaking the outer coating of the seed at once. Cultivation may then commence before the weeds get well started and the ground becomes hard and difficult to work.

168. Thorough preparation of the land before planting enables the farmer to work the crop with implements like the cultivator, that will cover a wide surface and do rapid work. *Good plowing* is the foundation of successful farming, and its benefits are apparent in all seasons and during all stages of the growth of the crop.

169 When land is drained and thoroughly prepared before planting, deep working of the crop is unnecessary. The one or two-horse cultivator with wide shovels, taking a row at one time going over, and cutting two or three inches deep, gives better results and does much more rapid work than such implements as the one-horse plow, or the bull tongue.

The first working of the crop may be deep (three or four inches), but after that, as a rule, shallow cultivation (about two inches deep) is not only sufficient, but is better for the crop, as it does not cut off the roots of the plants, thereby reducing their feeding powers.

170. From our own experience we find that but two implements in addition to the plow and harrow are necessary in working corn, cotton, and similar

crops, if the land is properly prepared, that is, drained and thoroughly plowed and harrowed. In corn, unless we can have a sod or some green growth to plow under for late planting, we invariably get the best results on heavy soils with least expenditure for labor, from deep fall or winter plowing, and shallow replowing, or fitting with the two-horse cultivator just before planting.

171. After planting, the land is harrowed broadcast with a Thomas smoothing-harrow, before and after the corn comes up, loosening the surface soil and destroying any weeds that may start with or before the corn. The loosening of the surface soil with the harrow causes the young corn to come up quick and grow off rapidly, and does away entirely with the "barring off" practiced in some States. The broad cast harrowing with a two-horse or three-horse team is quickly done, and it keeps down the weeds until the corn is large enough to be worked with the cultivator without covering the young plants. The first working is done with a one-horse or two-horse cultivator with sharp, diamond-shaped teeth; the later working, with wide, cutting, narrow-winged sweeps that cut not more than two inches deep and throw but little dirt to the rows.

For one horse, the 24 or 26 inch narrow-winged Dixon sweep is one of the best implements we have used in corn and cotton.

172. Besides destroying weeds, oft-repeated shallow cultivation of the crop retains moisture in the soil by checking the evaporation of water; causes a more rapid decomposition of plant food in the soil; converts nitrogenous matter into a soluble form; holds water deposited by showers and dew; warms up the soil in spring; and keeps the lower soil moist and cool in dry hot weather.

The more often the crop is cultivated, the more rapid the growth

173. Deep cultivation after the crop is partly grown, especially in very dry weather, will almost invariably injure the crop by cutting off the feeding roots. Late deep cultivation should not be practiced unless the crop is growing too rank, running too much to stalks and leaves.

174. The experience of our best farmers shows that on deep-plowed and well-drained land, hilling, or throwing dirt up to the plants, except in small quantities to smother small weeds, is an injury rather than a benefit.

175. Cultivating a crop with a turning plow is a slow process and should not be practiced unless the weeds and grass get such a start that smothering by burying is the only economical way to get rid of them. Such a condition is inexcusable, except in very wet seasons when continued rains for a week or two keep the land so wet that all work on the crop must cease.

CHAPTER XIV.

Manures.

What is meant by Manure.—The Value of Manure.—Value of Food and Excrements for Fertilizers.—Nutritive and Manurial Value.—Variation in Value of Manure from different Animals. How to Retain Fertility.—Liquid Excrement.—Waste Products.—Manure on Good and on Poor Land.

176. Manure is a term applied to any material that will, if added to the soil, supply plant food in an available condition to the crop, as well as to any material that will render soluble inert plant food already stored up in the soil.

177. As commonly understood, manure means animal excrements; or these excrements mixed with the litter that accumulates in stables and barn-yards. The value of any manure is determined by the condition, the kind, and the amount of elementary substances it contains. The manurial value of animal excrements is determined largely by the kind of food the animal eats, as the excrement will contain nothing that is not found in the food. The value of any

manure is largely determined by the amount of combined nitrogen, phosphates, and potash it contains, other elements required by plants are usually supplied by the soil and air; hence a food rich in these materials will make rich manure, and a food containing but small quantities of them will make poor manure, without regard to the kind of animal.

178. Except to make it more readily available to plants, the animal adds nothing to the fertilizing value of any food-stuff by eating it and converting it into manure. A ton of hay or a bushel of corn applied to the soil has as much fertilizing value as the manure made from feeding it to an animal, but the hay or corn might require more time to decompose and become soluble.

179. Wheat bran, cotton-seed, and linseed meal —valuable feeding stuffs for farm stock, are often applied directly to the soil as fertilizers, and are found to make profitable returns for the cost

180. All food-stuffs have two values: a nutritive, or feeding value, and a manurial value. If the food contains considerable quantities of nitrogen, of potash, or of the phosphates, it will make rich manure; and may also have high nutritive value. If made up almost entirely of starch or oily matter, it may still have a high feeding value, but be almost worthless for making manure.

181. The starch and oil which make up the principal part of corn have little if any manurial value, but are worth a good deal for food; hence it would not be advisable to use corn for manure, and the same is generally true of all farm products.

182. By feeding crops to animals, we may convert material in the crop of low fertilizing value into work, beef, milk, etc., and still have the greater part of all that is valuable for plant food left in the manure.

183. A young, growing animal stores up nitrogen, phosphoric acid, and potash, in building up the skin, lean meat, and bones; while the same materials are used by the cow in the production of milk. A grown animal, at rest, at work, or being fattened, uses or stores up, only carbon, oxygen and hydrogen, the fertilizing elements of the food passing off with the manure; therefore food consumed by such animals produces richer manure than if fed to growing or milking amimals.

184. Such foods as wheat bran, cotton-seed, or linseed meal, make rich manure, while corn, wheat flour, straw, poor hay, or any starchy or oily food that is made up almost entirely of carbon, hydrogen, and oxygen, makes poor manure. Some foods are rich both in food and manurial matter, cotton-seed ranking high in this respect. Hence to get the full value of cotton-seed it should be fed to stock, and the

manure made should be carefully saved, and applied to the soil instead of using seed for manure direct.

185. The most successful system of farming is that in which only such farm products are sold as contain small amounts of fertilizing material, the remainder being converted into animal products and manure.

186. In growing cotton, if the lint only is sold, if the seed is fed to cattle, and if the manure made is saved and applied to the land with the stalks, leaves, roots, etc., the planter could realize cash returns for the lint and for the animal products, while but a small amount of fertilizing material would be removed from the farm.

187. In wheat-growing, if the straw is used for feed and bedding, and as much wheat-bran as the wheat contains, or concentrated food of any kind containing the same manurial elements, purchased and fed out to stock, and the manure applied to the soil, wheat would not be an exhaustive crop.

188. Milk contains considerable quantities of fertilizing material, therefore growing crops to feed to cows to make milk to sell, exhausts the fertility of land nearly as rapidly as selling the crops, unless fertility is restored through the purchase of feed-stuffs. On dairy farms where the sales are limited to butter, and the skim milk is consumed by calves or pigs and

the manure applied to the land, the fertility of the land need not be exhausted, as butter has no manurial value. Growing animals store up fertilizing material in their bodies, but the amount is small compared with the total amount in the food consumed. Fattening animals excrete all of the fertilizing material.

189. In considering the manure question it should be borne in mind that the liquid excrement of animals is of as much value as the solid excrement, and special pains should be taken to prevent its loss.

190. All the waste products of the farm should be converted into manure by being fed to some kind of stock or used as litter to absorb liquid manure, and a considerable portion of most farms should be devoted to growing crops for stock feed to make manure, looking to returns from animal products sold, to pay for cost of growing. On the majority of farms, stock growing of some kind is necessary to keep up the fertility of the soil and reduce the expense of labor in order to make the farm profitable.

191. The manures make better returns when applied to good land that is well cultivated, than they do when used on poor land poorly cultivated, if we except new land in which there is sometimes an excess of organic matter and plant food.

192. On large farms, with moderate working capital, or meager equipment, the most profitable

returns will be secured by concentrating the manure produced and the labor expended in growing crops on the best land, and devoting the balance to pasture. The thoroughly tilled and liberally manured land will return a profit; while the poor land, even if it does not make large returns, costs almost nothing in the way of labor, and, if not too heavily stocked, will slowly improve in condition.

CHAPTER XV.

Commercial Fertilizers.

Composition of Fertilizers.—Land Plaster.—Guano.—Materials from which Fertilizers are made.—Phosphates.—Kainit.—Nitrate of Soda.—Value of Fertilizers.—Fertilizer Laws.—Value of Guano.—Bones.—Acid Phosphate.—Kainit.—Cotton Seed Meal.—Standard Fertilizer.—Value of Cotton Seed.—Barn-yard Manure.—Lime.—Special Manures.—Quantity to apply.

193. Commercial fertilizers is the name given to the artificial manures that are offered for sale in our markets. The fertilizers are made from materials containing more or less combined nitrogen, phosphates, potash, and lime. Lime alone, either fresh or air-slaked, is used to improve the fertility of land, but it is more often used in the form of land-plaster, also known as gypsum (sulphate of lime), or in the form known as phosphate of lime, an ingredient of most fertilizers sold on the market.

194. The first commercial fertilizer to come into use on the farm was guano. This material consists of the excrements of birds. It is or was found in

large quantities in countries where there is little or nó rainfall, where these deposits have been accumulating for many years. The largest deposits have been found in Peru; hence, the name Peruvian guano. The best guano contains in some cases eighteen per cent. of ammonia, and five and one-half per cent. of phosphoric acid. It is a very strong and active manure.

195. At the present time the supply of guano is nearly exhausted, therefore the limited supply and cost of transportation has led dealers in fertilizers to seek other sources for a supply of materials rich in plant food.

196. All kinds of refuse products that contain one or more of the three valuable manurial elements and lime, are now used in the manufacture of fertilizers. Phosphate rock, bone-ash from the sugar refiners, bones, kainit (sulphate of potash), muriate of potash, dried blood, fish-scrap, dried refuse from slaughter-houses, refuse from gas works, nitrate of soda, cotton seed meal, and many other materials. Gypsum and marl are often added to highly concentrated matter to give bulk and weight to the compound.

197. The fertilizer manufacturer uses any of the above materials which supply ammonia, potash, and available phosphates at the least cost.

198. The phosphate rock consists of fossil animal remains, or rock containing large amounts of

phosphate of lime. The same material makes up the principal part of bones. Large deposits of phosphate rock are found in the Carolinas and other places. The rock is ground up fine and treated with sulphuric acid to make the phosphoric acid soluble, and after being thus treated it is considered of a value for fertilizing purposes equal to bone.

199. Kainit, or the German potash salts, is found in extensive deposits in Germany. Kainit supplies the larger part of the potash used in fertilizers, owing to its low cost as compared with other material containing potash.

200. Nitrate of soda is found in Peru, but not in sufficient quantities to make it cheap enough to be largely used in compounding fertilizers. It is valuable for the large amount of readily available nitrogen it contains. One of the cheapest sources of nitrogen for the Southern fertilizer manufacturer at present is cotton seed meal.

201. The value of commercial fertilizers is determined by the amount of combined nitrogen, soluble phosphoric acid, and potash they contain, each ingredient being estimated at so many cents per pound.

202. The average price of these materials for 1887 at some of the manufactories is estimated at sixteen cents per pound for nitrogen, seven and one-half cents per pound for available phosphoric acid, and five cents per pound for potash. The value of

these three ingredients varies to some extent when derived from different materials, but the above represents average values.

203. In the older and more progressive States laws have been enacted requiring manufacturers of fertilizers to have their goods inspected by a competent chemist, or to furnish a statement with each package showing what proportion of the three manurial elements the fertilizer contains.

204. From the above estimate the value of good Peruvian guano is rated as follows:

2000 lb, 1 ton.	18% nitrogen = 360 pounds @ 16 cents = -	$57.60
	5½% phosphoric acid = 110 lbs. @ 7½ cents =	8.25
	Value of 1 ton - - - - -	$65.85

205. Fresh-ground bones treated with sulphuric acid contain about two and one-fourth per cent. of nitrogen, and seven and one-fourth per cent. of soluble phosphoric. One ton would, therefore, contain

45 lbs. ammonia @ 16 cents = - - -	$6.20
345 lbs. soluble phosphate @ 7½ cents = -	25.87
Value of 1 ton - - - - -	$32.07

206. Acid phosphate (Carolina rock) ground and treated with acid contains about 11.40% of available posphoric acid and 1.1% of potash. One ton would contain:

228 lbs. phosphates @ 7½ cents = - -	$17.10
22 lbs. potash @ 5 cents = - - -	1.10
Value of 1 ton - - - - -	$18.20

207. One ton of kainit contains about two hundred and thirty pounds of potash, which, at five cents per pound, would be worth $11.50.

208. Cotton seed cake or cotton seed meal contains to the ton about

135 lbs. of nitrogen @ 16 cents = - -	$24.60
61 lbs. phosphoric acid @ 7½ cents = -	4.57
36 lbs. potash @ 5 cents = - - -	1.80
Value of 1 ton - - - - -	$27.97

209. Cotton seed meal sells now for about $20 per ton in the vicinity of the oil mills in the Southern States, and acid phosphate and kainit sell for about the values given at seaport towns. Cotton seed meal at the present price is one of the cheapest fertilizers that can be purchased. It contains too much nitrogen in proportion to the amount of the phosphates and potash to give the best results on some soils and with some crops; but any desired proportion can be readily obtained by mixing cotton seed meal with acid phosphate and kainit, thus making a complete fertilizer.

210. A standard fertilizer, containing eight per cent. to eleven per cent. of phosphoric acid, two to two and one-half per cent. potash, and two and one-half to three per cent. of nitrogen in the form of ammonia is sold by dealers at from $30 to $40 per ton. Eight hundred pounds cotton seed meal, one thousand pounds acid phosphate, and two hundred

pounds kainit, well mixed together, will make a fertilizer containing nearly the above proportions of nearly equal value to the goods prepared by the manufacturer, and at a cost considerably less.

211. In the process of milling the cotton seed oil manufacturer extracts above two hundred and fifty pounds of oil, and seven hundred and fifty pounds of cotton seed meal from one ton of seed. The hulls make up the remaining one thousand pounds. The oil has no value as a fertilizer, and as the hulls contain not much besides carbon, hydrogen, and oxygen, and a small amount of potash, they have a low manurial value. The cotton seed meal in the ton of seed, estimated as before (two hundred and eight), would be worth about $11; one thousand pounds of cotton seed hulls about $1.25, making a ton of seed worth $12.25 for manure, estimated in the same way that the factory value of commercial fertilizers is determined.

212. According to Dr. Voelcker, chemist of the Royal Agricultural College, England, one ton of good barn-yard manure, composed of horse, cattle, and hog excrements, with the litter used for bedding, was found to contain twelve and three-fourth pounds of nitrogen, six and one-half pounds of phosphoric acid, and thirteen and one-half pounds of potash.

12¾ pounds nitrogen @ 16 cents = - -	$2.04
6½ pounds phosphoric acid @ 7½ cents =	.48
13½ pounds potash @ 5 cents = - -	.67
Value of 1 ton of manure - - -	$3.19

213. It must be remembered that the values given above are comparative values, based only on the nitrogen, phosphoric acid, and potash contained. Besides these elements the lime in barn-yard manure and cotton seed has some value, and the litter and hulls add organic matter to the soil, thereby improving its mechanical condition and its productiveness.

214. Lime alone is sometimes used as a fertilizer. It acts as plant food on land deficient in lime, but adds to the crop usually by helping to decompose material already in the soil. On soil filled with organic matter, it will often produce very marked results; but on old, cleanly cultivated land it will not take the place of the combined fertilizers. Land plaster, applied as a top dressing after the crop is up, promotes the rapid growth of certain plants on some soils. On young clover, beans, peas, and similar plants, it will sometimes give as good results as the complete fertilizers, and often better results at much less cost. Plaster is used extensively by farmers who grow wheat, corn, and clover in rotation; on the young clover to increase the growth of the clover.

215. Some soils and crops require only nitrogen,

others potash, and others phosphates in order to get the best results for the expenditure. Small plots of ground should be fertilized with manures containing a large amount of each one of these ingredients, and the yield of the different plots compared to learn which mixture or proportion will give best results on the soil tested. The farmer can then mix his fertilizer to suit his land and crop.

216. The quantity of fertilizer to apply to an acre of land can not be definitely stated. In garden farming one thousand pounds is sometimes used with the most profitable results. On average farm land for the ordinary crops from two hundred pounds to three hundred pounds of a standard fertilizer (see 210) is the quantity most commonly used.

217. Chemical analysis of the crop and determination of the quantity of each element drawn from the soil and removed will by no means indicate the quantity or proportion of manurial elements that should be applied to the soil to give the best result in growing the crop. The soil may contain in available condition all that is needed of one or more of the substances required, and again some crops will utilize material that other crops can not appropriate, owing to the difference in feeding power of the roots.

CHAPTER XVI.

Care of and Composting of Manures.

Stable Manure.—Fresh Manure.—Solubility.—Litter.—Composting.—When Desirable.—Comparative Value of Stable Manure and Concentrated Fertilizers.—Care of.—Time to Apply.—How to Apply.—Top Dressing.—Plowing under.—Hill Applications.—Plan Followed by Author.

218. Stable manure decomposes rapidly and is subject to loss of valuable constituents if it is not properly handled. If allowed to heat, nitrogen, in the form of ammonia, will escape, and if the manure is thrown out into an open yard, soluble matter will be washed out with every rainfall. To prevent loss of fertilizing value, manure should be handled in one of the following ways: 1. Allowed to accumulate in the stables until needed. 2. Hauled direct to the field from the stalls every day as fast as it is made. 3. Piled up in the yard in compact heaps. 4. Piled up under a shed to protect from rain until it is convenient to haul on to the land.

To prevent loss from leaching, the winter rains make it necessary in the Southern States, to keep

manure under shelter until it can be put on to the land.

219. Green or fresh stable manure must decompose before it will become soluble and furnish available food to the plant; hence composted manure gives more immediate returns than fresh manure. Stable manure from horses or mules will heat, if piled in large heaps, and ammonia will escape into the air. Cattle and hog manure, containing more water and being less active, will not heat readily, and when mixed with horse manure will prevent rapid decomposition of the mass.

220. Leaves, dirt, trash, and refuse of all kinds are often used for bedding to make the animal comfortable, and to absorb and hold liquid manure. Such refuse materials are sometimes added to manure in making compost heaps. When used to absorb and hold liquids that would otherwise be wasted, such practice may be profitable; but when added to manure in a compost heap to increase the quantity of the compost, the extra cost of labor in handling the added material may exceed the value of the increase in crop resulting from the application, unless the refuse materials contain considerable amounts of fertilizing elements.

221. On garden-farms, where land is costly and the manure is hauled but a short distance, composting refuse material with stable or concentrated manures

is usually found profitable; but on large farms the same results may be secured with less expenditure for labor by using the concentrated fertilizers in connection with green manuring, growing clover, cowpeas, and similar crops to rot on the ground or plow under.

222. A ton of good stable manure has been found to contain from twelve to fifteen pounds of nitrogen, six to eight pounds of phosphoric acid, and thirteen to fitfeen pounds of potash, which, estimated at the same rate as was given for commercial fertilizers in the last chapter, would make the ton of manure worth about $3 50 and equivalent in manurial value to about 175 lbs. of cotton-seed meal and 80 lbs. of Kainit. Stable manure made from feeding corn, with a poor quality of hay, and using straw for bedding and for a liquid absorbent, would not be worth more than two dollars per ton, estimated as above; and it would be equivalent to not more than 100 lbs. of cotton-seed meal and 50 lbs. of Kainit.

223. The organic matter in the manure would improve the mechanical condition of the soil and add organic matter to it, (see 49) but on good average soil the application of a mixture of cotton-seed meal and Kainit would give a larger increase in crop owing to its being more readily available. It would also cost much less to apply it.

224. One of the best plans for handling manure on the farm, when it can not be hauled direct to the fields, is to wheel or cart the manure from the horse and cattle stalls and from the hog pens, with an occasional scraping up of the barn-yard, to a pile under a shed The liquid manure should be added to the pile and the mass should be tramped down and kept just moist enough to prevent over-heating, but not to prevent a slow decomposition Treated after this method, the ingredients that contain plant food would break up and become soluble, the excess of water would evaporate and the pile of manure would decrease in weight and bulk, and increase in richness, thus reducing cost of hauling and application. Bones may be utilized by breaking them up with a heavy hammer and burying in such a compost heap Carcases of dead animals may also be cut up and added to it with good results.

225. From the protected compost heap just described, the manure may be hauled to the field at any time during the year that is most convenient.

The time of year to apply manure to get the best results from the application is not a matter of serious importance on farms where diversified crops are grown. Readily soluble, quick-acting fertilizers should not be applied any considerable length of time before a crop will be growing on the land, as loss may occur from the soluble part of the fertilizer, being

washed out in the drainage water, or carried too deep to be reached by the plants. Such fertilizers as fresh stable manure, the phosphates, cotton-seed, and other slow-acting manures had better be applied sometime before the crop is planted to give time for decomposition. Grass lands may be fertilized at any time during the year with good results.

226. Manure is applied to the soil in a variety of ways; distributed broad-cast upon the surface, called top dressing; plowed under, applied in the hill or several applications made during the season to the growing crop. All of the different methods of application are advocated, and each one may be found desirable under certain circumstances.

227. In the method of applying manure two things are to be considered: first, benefit to the crop; second, cost of application. The cost of manure and expense of application will have a good deal to do in determining the quantity to be used, system of farming, and crops to be grown. Indirectly it may influence the entire management of the farm.

228. The cheapest method of applying coarse barn-yard manure is to spread it over the ground broad-cast, and the practice of letting it lie on the surface, or simply harrowing it in after the ground is plowed, is becoming more popular every year with our best farmers. Treated in this way the manure as it decomposes is washed into the soil with every rain-

fall and evenly distributed to the roots of plants. Plowed under, decomposition takes place slowly and a considerable portion of the manure may be buried below the larger part of the feeding roots of the plants. This is especially true on deep plowed, heavy, close soils, that are not well drained.

229. Plowing under a large quantity of coarse litter, or crop grown on the land, may lighten up a heavy soil and give good results from the improvement made in its texture, but the plant food will not become so quickly available as from surface application. Simply covering the soil with anything that will shade it, seems to be beneficial, so much so, that it is a debated question as to there being any gain in plowing under a crop of clover, cow peas or similar crops when nearly or fully matured, over letting it rot on the surface.

230. With a limited amount of manure the best returns for one year may be secured from hill and drill application, as the roots of the plants reach the manure at once, but coarse manure applied in the hill may cause the soil in which the plant is growing to become too dry during a drought and reduce the crop. Hill and drill application makes extra labor unless the concentrated fertilizers are used and put in with the drill along with the seed at one operation.

231. In our own practice we have adopted the plan of applying all stable manure as a top dressing,

broad-cast, and the concentrated fertilizer in the drill with the seed, or just as the crop is coming up. We use no refuse material for making composts, except the litter used for bedding for the stock, and apply the concentrated fertilizer alone to the soil, rather than go to the expense of employing labor to combine them with materials not rich in plant food and the added labor necessary to apply the compost. Our system of farming includes growing clover, cow peas, and other crops that leave organic matter in the soil on all land cultivated, thus obviating the necessity for supplying it in the manure.

CHAPTER XVII.

ROTATION OF CROPS.

Effect of Rotation.—Why Rotation is Desirable.—Difference in Assimilation.—Root Growth.—Material Left in Soil.—Diversity of Foliage.—Red Clover.—Cow Pea.—Value of Roots—Rotations.—Other Advantages.

232. Experience has shown that as a rule when one crop is followed by a crop of a different kind, land will be more productive than under the single crop system. The best results are secured both in increase of yield and economy in labor by having clean-cultivated crops such as corn, cotton, Irish potatoes, etc., alternate with grain, clover, cow peas, and grass crops. A crop of weeds allowed to grow and decay on the land will be beneficial so far as adding to the fertility is concerned; but, if the weed seeds are allowed to ripen, it may add to the expense of keeping succeeding crops clean.

233. Plants vary widely in the following particulars:

1. Power of assimilating by means of their roots the plant food in the soil.

2. In the proportion of the several plant food elements taken up.

3. In the extent and depth of root development

4. In the amount of plant food left for succeeding crops in the roots that remain in the soil.

5. In the density of foliage and consequent power of shading the soil, or inpaucity of foliage, thus leaving it exposed freely to the sun and air.

234. Careful study of the above peculiarities of plants shows why a rotation of crops may be more profitable than planting the same crop continually; and it will suggest a desirable rotation to the intelligent farmer.

235. The two most valuable plants for improving the fertility of the soil, and, consequently, for inclusion in the rotation practiced on American farms are red clover, and the cow pea. The former is valuable over nearly the entire country; the latter, in the Southern States. Red clover and the cow pea are deep rooting plants, and have strong feeding powers. They shade the soil with a densely matted growth that will choke out weeds; they furnish a large amount of either hay or ensilage of the best quality which is rich in both nutritive and manurial matters, and they leave in the soil for succeeding crops a large quantity of roots, rich in plant food.

236. The cow pea, of which there are a number of varieties, has some advantages over the red clover

on farms in the South. It will grow on poorer soil, and it makes full development in from four to six months; consequently two crops can be grown during the year, and the growth may be cut for hay, pastured off by stock, or plowed under. The red clover is a biennial requiring two years to make full development in the northern half of the country.

237. When either red clover or the cow pea is grown on land of average fertility: after cutting off the crop for hay the roots and stubbles on and in the soil contain as much nitrogen, potash, and phosphoric acid that may become available to the succeeding crop as will be found in 300 to 600 pounds of cotton-seed meal, or one-fourth of a ton of a good standard fertilizer. In addition to supplying available plant-food to succeeding crops, the red clover and cow pea roots leave large quantities of organic matter in the soil, thereby improving its mechanical condition.

238. A rotation that is found desirable in some of the Northern States runs five years: first year, corn; second year, oats or barley; third year, winter wheat, on which clover is planted in the spring; fourth and fifth years, clover, or clover and timothy together.

This rotation provides a clover sod to plant corn on, and insures a good crop of corn with a moderate amount of labor; while the sod, roots, etc., have time to become thoroughly broken up and decomposed,

and the soil can be made clean for the succeeding grain crops. A four-year rotation may include only corn, wheat, and clover.

239. In the Southern States, where red clover will grow, a five-year rotation might include: 1st year, corn; 2d year, clover sowed on the corn stubble in the spring; 3d year, clover, cutting first crop for hay, second for seed; 4th year, oats, followed by cow peas as soon as the oats are harvested; 5th year, cotton. Either the cotton or the oats may be left out and the rotation allowed to run but four years. Different rotations may be planned to suit the needs of the farmer.

240. Other advantages of the diversified system of farming and the rotation of crops over the single crop system, are gained in having the work spread over the entire year, and in having less land planted to crops that require cultivation. With the farm work so arranged that one-third of the land will be planted to cultivated crops, one-third to hay and forage crops, and the remaining third set in pasture by carrying enough stock of some kind to consume all of the food grown on the farm, the cost of labor may be very much reduced and the fertility of the soil retained and even increased without materially decreasing the returns from crops grown and sold.

CHAPTER XVIII.

Farm Live Stock.

Origin.—Wild and Domestic Animals.—Wild state.—Natural Variation.—Race Qualities.—Peculiarities of Breeds.—Breed Defined.—Formation of a Breed.—Improvement.—Retention of Qualities.—Prepotency.—How to improve Common Stock.—Effect of Neglect.

241. From the earliest times domestic animals, the live stock of the farm, have been used by man for various purposes. It is supposed that all of the domestic animals existed first as wild animals, but were caught and tamed as men found they could be made useful.

242. Cattle, horses, sheep, and hogs that are believed to be similar to the animals from which our present families of live stock have descended, are still found running wild in some parts of the world among half civilized tribes and semi-barbarous nations. The domestic animals seem to be intermediate between the wild and the fully domesticated animals.

243. The domestic animals, with the exception of the dog and cat, include only such as feed wholly or in part upon vegetable products. These animals have been so modified by domestication that they often possess qualities not found in the wild varieties of the same species.

244. In the wild state animals simply have the power of securing a living and reproducing their kind. Under domestication they acquire new habits and the power of making some return in the way of work, flesh, milk, or wool in addition to the preservation of existence. The wild cow simply furnishes enough milk to rear her calf, but under domestication she is able to provide for her calf and supply milk for the use of man. The sheep has been made to produce heavy fleeces of wool, and the meat-producing animals large quantities of meat.

245. In a wild state animals are modified by food and climate. In a temperate climate, with food plentiful and easy to be secured, animals tend to increase rapidly, grow to large size, and are of a quiet disposition. In a cold climate, where food is scanty and not easy to be secured, animals grow slowly, are small, active, and hardy, and do not increase as rapidly as they would under more favorable conditions.

246. The same effect is produced under domestication, and from the same causes where man does

not counteract these influences by selection in breeding and varying the food and shelter supplied.

247. The qualities of a race are the result of natural influences, but the qualities of an improved breed are artificial, being developed only by special treatment.

248. The difference in the breeds of families of domestic animals is due to the influence of man. By persistent and systematic treatment the characteristics of our breeds of stock may be changed to meet our wants. In this way have been produced the trotting and running horses, possessing wonderful speed; the draft horse, with great strength and large size; the Jersey cow, yielding from two to four pounds of butter per day; the shorthorn, producing its great mass of flesh; the merino sheep, a heavy fleece of the finest wool; the remarkable intelligence of the hunting, shepherd, and watch dogs.

249. These changes can be accomplished only by long-continued exertion on the part of man, and, when established, are retained only so long as the animal is subject to the same conditions under which they were produced.

250. Turned out to run wild, the improved breeds of animals will lose their valuable acquired qualities, and deteriorate in a few generations to the condition of the animals from which they descended.

251. Breed is the name given to a class of animals that have acquired new and valuable qualities through the agency of man. Before any family of animals can properly be classed as a breed, they must have been bred by themselves until they are similar in shape, size, color, habits of growth, etc., and they must have these qualities so well fixed that they will be transmitted to the offspring with a good deal of certainty. Breeds are made by deciding upon the type of the animal to be produced; second, by selecting such animals, male and female, as come nearest to this type, and breeding them together; third, by selecting such of the offspring as approach still nearer to the type, and rejecting all others. In addition to breeding from selected animals only, a system of feeding, training, and general care must be adopted that will help to develop and fix the qualities desired.

252. Formation and improvement of any breed of animals should be sought, first, in the careful selection of the breeding stock. To enable one to make a proper selection requires a degree of skill and soundness of judgment, such as can only be attained by long experience in handling and caring for stock. Careful selection of the stock to breed from is necessary not only in the formation and improvement of the breed, but it must be kept up continually after the breed is established to prevent deterioration and loss of qualities that have been secured

by a long and careful system of breeding. The improvement in a breed being due to food and care as well as to selection in breeding, the improved breeds must have a more regular and better supply of food than is often thought necessary for common stock. The improvement made in the native animal in the formation of a breed consists of artificial qualities that have been developed under artificial conditions. The tendency of the animals thus formed is to breed back to the starting point whenever the conditions are removed under which the artificial qualities were produced.

253. The older the breed, or, in other words, the longer the time during which a family of animals have been kept under the same conditions as regards selection in breeding and care, the more fixed will be the characteristics of the breed. Purely-bred animals of the well-established breeds will transmit their peculiarities to their offspring, even when a male or female of the pure breed is bred to an animal of a different kind that is not purely bred. This power of an animal to transmit the qualities possessed is called "prepotency," and it is one of the things that makes the improved breeds of so much value to the grower of common stock.

254. The farmer may lack the skill and taste that is necessary to enable him to retain the good qualities possessed by an improved breed of stock, but

by the occasional purchase of pure-bred males to breed to his native or grade females, he may secure, to a considerable extent, the merits of the pure breed in the offspring produced, owing to the pure bred sire having greater prepotency than the inferior female, and thereby impressing more of his peculiarities on the offspring than will be inherited from the dam. The purchase of one pure bred male will enable the farmer to improve the offspring of a large number of inferior females. The improvement that can be secured in this way is so marked that the most intelligent class of farmers in the country will use only pure bred males if they can be procured by any reasonable expenditure of time and means.

255. It has been stated that the longer the time that a breed has been purely bred the stronger will be the prepotency of the individuals of the breed. For this reason a grade, the offspring of a pure breed animal and a native, will not transmit his qualities with equal certainty to a pure bred animal, although he may in appearance, growth, etc., closely resemble his pure bred sire. No greater mistake can be made than to select a male to breed from and judge him by his appearance without regard to the way in which he was bred. Yet the appearance of the animal is the one thing that governs the choice of a sire with too many farmers. All skillful stock breeders carefully examine the pedigree of animals selected for breeding purposes, and reject any animal not descended

from well-bred ancestors without regard to his excellence as an individual. They have learned that individual excellencies may be accidental, and are not apt to be transmitted, while qualities inherited from pure bred ancestors are almost certain to be impressed upon the offspring.

256. In the improvement of common stock by the use of pure bred males, it must be remembered that the good qualities of the pure bred male are partly the result of extra food and care; therefore, if the grade offspring are expected to develop and possess the qualities of the improved breed instead of the native, they must to some extent be supplied with the conditions that helped to make the improved breed.

257. All of the large yielding varieties of plants require good soil and thorough cultivation; and all of the large and rapid growing breeds of animals, and the cows that yield large quantities of milk and butter, are great eaters. Planted in fertile soil and supplied with plenty of food, the improved plant and the improved animal will make better returns for material consumed and labor required than the inferior varieties that flourish under less favorable conditions. The careless and indifferent farmer, who practices poor cultivation, and compels his stock to make their own living, will gain nothing in adopting either improved varieties of plants or improved

breeds of stock. On the other hand, the thrifty and careful farmer can not afford to make such poor use of his time and opportunities as to expend them in growing and caring for an inferior class of stock that at the best will make but light returns.

CHAPTER XIX.

Diversified Farming.

Special Farming.—Diversified Farming.—Advantage of Diversified Farming.—When most Desirable.—Saving in Labor.—Cost of Plant Food.—Returns from Animal Products.—Cheap Sources of Plant Food.—Conclusion.

258. Farming, as generally practiced, may be classed either as special or as diversified farming. The former means devoting the farm to one or two crops; the latter, to a variety of crops. The cotton plantation of the Southern States, where cotton and corn are often the exclusive crops, and the wheat farms of the Northwest, that are planted entirely to wheat, are examples of special farming.

259. Diversified farming as generally understood means growing several crops, and also stock of some kind to convert a portion of them into animal products, such as butter, meat, wool, etc , that may have a higher market value than the crops would sell for and at the same time furnish manure.

260. A variety of opinions is found to exist among the most intelligent and successful farmers as to which

system is preferable. It is held by some men that the diversified system should always be practiced, although they may not agree as to the extent of the diversification; while others claim that a farm devoted to a specialty, can be conducted with greater economy and more profit than if the labor of the farm is diverted in several directions. Some agricultural writers advocate combining the two systems in such a way as to make some one product a specialty, devoting to it the main energy of the farm with the expectation of deriving from this product the cash income of the business, while at the same time they advise us to practice diversified cropping to the extent of supplying the farm with renovating crops, food crops, and manure.

261. Some of the advantages that may be derived from the alternation of crops have been shown in chapter XVII.

It may be found, however, that in some localities all of the benefits to be secured from rotation and diversity of crops may be secured in a more economical way and the farm made more profitable by confining the work to special crops. Such may be, and often is, the case on high-priced land near cities, from which garden truck may be easily sent to market and where the rental value of the land makes it cheaper to buy manure to supply plant food to the soil than to resort to restorative crops.

The same may be true on new and highly productive soil, such as is sometimes found in rich river bottoms and prairie lands that are specially adapted to growing some crop commanding a high price in the market, and also on lands where labor can be secured whenever it is required.

262. Diversified farming is generally desirable on land that has been under cultivation for a long time, and especially so on light soils. Where a variety of crops are grown, the preparation of the land for planting, the cultivation, and the harvesting occur at different seasons of the year, thereby giving steady employment to a regular number of men and teams. When combined with stock growing, a home market is provided for the consumption of the heavier and coarser products of the farm that are costly to transport to market.

263. Of still greater importance in the economy of the farm is the low cost of plant food that may be supplied by diversified farming and stock growing, and the amount of land that may be made profitably productive in proportion to the expenditure for labor.

264. If the larger part of the farm is planted to corn, cotton, and other crops that require cultivation, the work of one man and team will be expended on a small era of ground, and after the virgin fertility of the soil is partially exhausted, fertilizing material must be procured from some outside source to supply

the plant food required to produce a profitable crop. If, instead of cultivating so much land, one-half of the farm is utilized for pasture, hay, and grain crops, the labor will be much less, the forage may be converted into animal products and manure, and the fertilizers required from outside sources to prevent exhaustion of the soil largely curtailed in amount.

265. By contracting the area of cultivated crops still further, turning say, one-third or even one-half of the farm into pasture, and planting one-half of the remainder in hay and forage crops, and the remaining portion in cultivated crops, and by increasing at the same time the number of stock to the extent of consuming all the food that the farm will supply, the cost of labor may be still further reduced and sufficient fertilizing material to prevent deterioration of the land supplied from the farm.

266. Owing to the fact that an acre of land may be made to make as large a return by growing a crop that may be converted into beef, milk, or other animal product, and selling these, as by growing a sale crop—counting the cost of labor and rental value of the land on the average farm. The advantages of growing feed crops over growing exclusively sale crops are evident when we remember that under the former plan the land will increase in productiveness, if the manure made is returned to the soil, while in growing sale crops, it must deteriorate, unless we

resort to the purchase of fertilizers that are not made on the farm.

267. The productiveness of the soil of the farm may often be increased by purchasing concentrated foods that are rich in nitrogen, phosphates, and potash, and by feeding to stock.

268. Such feed stuffs as cotton seed, cotton seed meal, linseed meal, wheat bran, glucose meal and the by-products of distilleries, malt houses, and the like, as well as some of the cereals, are rich in both nutritive and manurial matter. Some of the above or similar feed stuffs can be purchased in almost any part of the country at a cost that will enable the farmer to convert them into animal products at a profit, and add largely to the supply of manure at the same time.

269. It often happens that a concentrated food may be purchased so much below its value for fertilizing purposes that the manure resulting from its consumption will be worth more than the cost of the food, while at the same time the food will more than pay for its cost in animal products. For the reason set forth, the shrewdest farmers of England and America prefer to purchase concentrated foods to feed to stock for the purpose of enriching their lands, rather than to buy the commercial fertilizers.

270. To reap all the advantages of diversified farming, the farmer should include the pasturing of

stock and the growing of hay crops to reduce the labor of the farm; the alternation of crops, to secure the benefits of rotation and renovation of the soil from the root-growth of certain plants, and the purchase of concentrated feed stuffs to enable him to carry more stock and make more manure.

CHAPTER XX.

Food and Manure Value of Farm Products.

Nutritive Value.—What Food is Converted Into.—Digestibility.— Animal Waste.— Value of some Knowledge of Chemistry. — Selling Fertility. — Farming by Rule.—Effect of Feeding the Crop Grown on the Farm.—Table of Manure-Value of Feeding Stuffs. — Losses in Feeding. — Market Value vs. Feeding Value.—Value of Pemanent Meadows and Pastures.

271. The several products of the farm have a double value; first to supply nutrients to support animal life; second, to supply plant food to the soil. The nutritive value of any farm product is determined by its composition and the digestibility of the materials of which it is composed.

272. Starch, fat and other combinations of oxygen, hydrogen, and carbon, in the food, are converted into animal heat, muscular force, and fat; the nitrogenous portion, into lean meat, skin, hair, gelatine of the bony tissues, and with all parts of the animal containing nitrogen; the ash elements of the food into bone and into the ash element found in the dif-

ferent parts of the body. The food eaten is not all digested and assimilated, a portion, varying from ten to seventy per cent. passing through the animal as inert matter, and appearing in the solid excrements.

273. The different parts of the body of the living animal are constantly wasting away, while at the same time they are being built up again from material supplied by the food.

With the exception of the carbon, oxygen, and hydrogen of the food, the waste material of the body, including the undigested food, is thrown off in the solid and liquid manure, unless the animal is giving milk. From the above statement it will be seen that all the portion of the food consumed by the animal which is valuable for manure is either stored up in the body, converted into milk or it is excreted as solid and liquid manure.*

274. To enable the farmer to grow and feed crops in such a manner as to secure the largest returns and at the same time retain fertility on the farm, for his labor, some knowledge of chemistry is required, that he may know what he should feed and what he may sell. As a general rule no crop valuable for feeding and at the same time containing considerable matter valuable for fertilizing purposes should be sold, unless

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* Carbon, hydrogen, and oxygen are supplied to the plant from the atmosphere; hence are not necessary in the manure.

it will sell for a price exceeding the cost of some other food stuff that contains a still larger amount of fertilizing material. Again, no sale crop should be grown and sold continually that removes considerable quantities of nitrogen, phosphates, and potash, unless an equivalent of these substances can be returned to the farm from some cheaper source, either in feed stuffs or in fertilizers.

275. Drawing fertility from the land to be sold in the crop, and purchasing fertilizing material from outside sources to supply the loss can hardly be compared to depositing money in a bank and checking it out again; for in the former case it is impossible to strike a balance-sheet to learn how the account stands. We have no means of ascertaining the amount and value of the original deposit, nor can we estimate the losses that may occur through the washing out of available plant food, atmospheric dissipation of gaseous matter or the accremutation of nitrogen from the atmosphere. These gains and losses are influenced to so great an extent by the peculiarities of the season, rainfall, temperature, system of cultivation, chemical changes taking place in the soil, and difference in the soil, that we can not determine the exact condition of the land at any one time, nor can we control, except partially, the changes liable to occur.

276. While our present knowledge will not enable

us to farm by rule, practical experience and scientific investigation have conclusively demonstrated certain general rules that may be modified by a thoughtful man to fit most cases We find, almost without exception, in growing crops which contain large quantities of the valuable manurial elements referred to through this book, that selling these crops and making no return to the soil, will in a few years, reduce the productive capacity of the land to the extent of making the land unprofitable to cultivate. Again, we find that when the mechanical condition of the soil is right, and the requisite amount of water is supplied, it may be made highly productive, no matter how poor, if the chemical constituents of the crop are added in sufficient quantity and in available form.

277. Practical experience has also shown that where the larger part of the crops grown on the farm are fed to stock and the manure is saved and applied to the land, the farm gains fertility and increases in productiveness, and scientific investigations explain why these results follow and they suggest how farming may be conducted so as to secure the best results. Tables are published in our argricultural journals, and in books by various authors which treat of agricultural subjects, giving the composition of all farm crops, and of the commercial products sold for feeding purposes, and for fertilizers

278. The following table gives the average

amount of nitrogen, phosphoric acid, and potash, found in some of the farm products common to the country, and in a few of the concentrated feed-stuffs offered for sale in our markets, with their manurial values. The nitrogen is estimated at 16 cents; potash 5 cents; and phosphoric acid at $7\frac{1}{2}$ cents per pound.

Table showing the average of nitrogen, phosphoric acid, and potash, found in one ton each of some of the common feeding stuffs.

	Nitrogen. lbs.	Phosphoric Acid. lbs.	Potash. lbs.	Value. \$. cts.
Clover Hay	39.4	11.2	39.	9.19
Timothy Hay	19.2	7.2	29.6	5.09
Corn Enselage	4.8	2.2	7.8	1.32
Corn Stalks	13.2	7.8	17.2	3.55
Oat Straw	10.	5.	20 8	3.01
Wheat Straw	9.6	5.2	11.6	2.50
Cow-pea Vines	50.2	8 2	28.0	10.05
Cow-peas	66.4	20.2	20 2	13.14
Corn (Maize)	33.8	14.2	8.0	6.87
Oats	41 2	12.4	9.0	7.96
Sorghum Seed	28.4	16.2	6.6	6.09
Corn and Cob Meal	22.9	10.9	9.2	4 94
Wheat Middlings	41.4	25.2	13.4	9.18
Wheat Bran	47.4	60.2	32.0	13.69
Gluten Meal	94.8	90.	1.2	15.90
Linseed Meal	95.	39.2	29.4	19.61
Cotton-seed Meal	134 6	60.6	35.8	27.87
Cotton-seed Hulls	7.0	1 8	26.4	2.57
Turnips	4.2	1.6	5.8	1.08

279. The value given in the above table may not represent the actual value of the several substances for manure, but they do represent approximately their value, compared with the commercial fertilizers sold in our markets. In other words the values are determined in the same way.

280. In feeding a certain amount of clover, hay, oats, corn, cotton-seed meal, or other feed stuffs to farm stock, it is estimated that from 60 per cent. to 90 per cent. of the fertilizing value of the food may be secured in the manure if it is protected from loss. It follows therefore that a feed stuff or farm product may, at times, have a higher value for manure when fed to stock than it will sell for in the market, in addition to its actual food value. We notice that timothy hay is worth but little more than one-half as much as clover hay for manure, yet timothy generally commands from 25 per cent. to 40 per cent. more per ton in the markets. Straw has a low manure value, yet it often sells as high as clover hay. Corn has a moderate manure value while cotton-seed meal and linseed meal have high values. Fed in the right way the cotton-seed and linseed meals are worth nearly twice a much, pound for pound, as corn for stock feed, yet in some sections of the country these meals cost but little more per ton than corn.

281. A careful study of the food, manure, and market values of crops grown, and feed stuffs that

can be bought, will often enable the farmer to sell some portion of his crop and with the return purchase its equivalent in food value, often more, and at the same time get double the manure value in the material purchased.

282. During the winter season in many places in the Southern States, a bushel of corn can be exchanged for cotton-seed, which will contain not less than three three times its equivalent in cattle food, and four times its value for manure.*

283. The practice of selling large quantities of hay from a farm is not to be commended, unless some means are taken to replace the loss of plant food. If, however, cotton-seed meal, wheat bran, or any feeding stuff rich in plant food is purchased and consumed, a portion of the farm may be converted into permanent meadow, and the hay sold without injury to the place. Meadow lands become impoverishd as readily as land under cultivation; hence, if it is desired to make the meadow permanently productive, the soil must be enriched the same as for cultivated crops. Permanent meadows and permanent pastures, well set in valuable perennial grasses, may often be made even more profitable than land nnder cultivation, as there is but

* In feeding milk cows and fattening cattle, our experiments at the College show that one pound of corn is equivalent in food value to not more than two and one-fourth pounds of cotton-seed. During the winters of 1884—5—6, we have sold corn at an average price of $20.00 per ton, and bought cotton-seed at $6.00 per ton.—*F. A. Gulley, Agricultural College, Miss.*

a small expenditure for labor. With the outfit of haying implements the entire labor on one acre of good meadow in growing and harvesting a crop of two and one-half tons of hay, may not cost more than from three to four dollars. The actual cost of cutting and storing hay is sometimes reduced to one dollar per ton with hay worth from $8.00 to $14.00 per ton. The cost of production in proportion to the value of the crop is less than with almost any crop that can be grown.

283. Pasturing land economizes labor to a greater extent than growing hay. With this crop there is no outlay for harvesting. The crop is put into condensed form for marketing by being converted into animal products, and even the manure from the consumption of the crop is returned to the land without expense. Pasturing land is the most economical method of making it productive; and, properly managed, the soil (unlike cultivated land) improves with use. The value of a good pasture is not so generally appreciated in America as in the older countries. In England the pasture lands command the highest rents, because the farmer has learned that grazing lands may be made to yield a greater return than the lands under tillage.